Tangential Water Wheels

The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

VOL. VIII.—No. 4. SAN FRANCISCO, CAL., OCTOBER, 1899. {YEARLY SUBSCRIPTION, $1.00 {SINGLE COPIES, - 10 CENTS

WESTON ILLUMINATED DIAL STATION INSTRUMENTS

These instruments are based upon the same general principle and are just as accurate as our regular Standard Portable Direct Current Voltmeters and Ammeters, but are much larger and the working parts are inclosed in a neatly designed dust-proof cast iron case which effectually shields the instrument from disturbing influences of external magnetic fields.

WESTON ELECTRICAL INSTRUMENT CO.

114-120 WILLIAM ST., NEWARK, N. J. U. S. A.

1889 PARIS EXPOSITION MEDAL FOR RUBBER INSULATION

OKONITE

TRADE MARK.

1893 WORLD'S FAIR MEDAL FOR RUBBER INSULATION

SOLE MANUFACTURERS OF

OKONITE TAPE : MANSON TAPE

CANDEE WEATHER-PROOF WIRES

THE OKONITE COMPANY, Ltd.,

Wilfrid H. Candee, H. Durant Chesver } Managers
Geo. T. Manson, General Superintendent
W. H. Hodgins, Secretary

253 Broadway, NEW YORK

General Electric Company

Schenectady, N. Y.

Claus Spreckels Building, SAN FRANCISCO, CAL.

Worcester Building, PORTLAND, OR.

Dynamos

Transformers

Lightning Arresters

THE STANDARD OF THE WORLD.

And . . All Electric Supplies. . .

Motors

Arc Lamps

Incandescent Lamps

Have you mislaid our catalogues?

Is the discount sheet missing?

"MAMMA"
From a painting by Mrs. Bruce Heston, in San Francisco Press Club Collection.

If you are in the market for

Incandescent Lamps Lighting Supplies

Power Motors Fan Motors Telephones

Sterling Varnish Mica and Micanite

or anything in the ELECTRICAL LINE, we are prepared to supply you from stock.

BROOKS-FOLLIS ELECTRIC CORPORATION

523-525 MISSION STREET,

Telephone MAIN 861 SAN FRANCISCO, CAL.

THE JOURNAL OF ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, OCTOBER, 1899. NUMBER 4.

*Tangential Water Wheels.**

BY W. A. DOBLE, M. E.

IN support of the contention that the development of tangential water wheels has been purely a matter of evolution from times of antiquity, are cited the works of Branca, 1629, A. D.; Euler, 1754; Borda, 1767; Navier, 1819; White, prior to 1822; Poncelet, 1827; Girard, 1843; Dingler, 1858, and almost innumerable others. Jearum Atkins in 1853 applied for United States letters patent (granted August 10, 1875), for a water wheel which embodied the

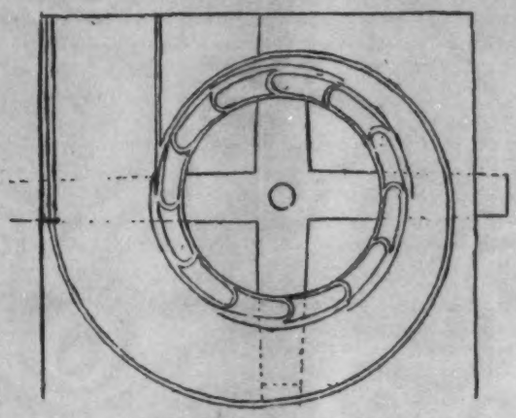


FIGURE 1.—THE ATKINS WHEEL.

fundamental principles of the modern tangential wheel; namely, that water be applied to the periphery of the wheel, that the peripheral velocity be one-half the jet velocity, that the direction of flow in the wheel be reversed so that the wheel may absorb the reactive energy of the jet, and that the water leave the wheel without velocity.[1] Independent of Atkins' researches, however, in the early fifties, the miners of California who had water available only in limited quantities but at high heads, developed the "hurdy gurdy" wheel, which was the legitimate forerunner of the modern tangential wheel. It was a crude affair, having an efficiency of about forty per cent. The origin of the name is of interest. If tradition is to be believed, the California miner who came to the Coast in forty-nine or the early fifties, spent his spare time in places of amusement wherein abounded the mirth of liquid cheer and round-about dances. They did not go through the minuet or other demure and stately functions in these dance halls, or "hurdy gurdies" as they were called, and the rickety, boisterous whirl of the dances which they did see—and perhaps (?) participate in—found so striking a counterpart in the whirl of the original jet wheel, that straightway it was dubbed a "hurdy-gurdy" and as such it has been known ever since.

The hurdy gurdy wheel was made of blocks of wood about four inches thick, cut out like the teeth of a circular saw, with teeth about eight inches apart. These teeth or buckets were then closed in by casings of wood which formed the sides of the wheel, and from these sides four arms, or spokes, were mortised into a log, the end of which was fitted with a round gudgeon for a bearing. The gudgeon was then placed in a live oak block which had previously been gouged out for the bearing, and this gouging out was generally very roughly done, because of the poor quality of tools which the miner of those days had at his disposal. The water was applied at first in the form of a jet emanating from a hole bored into the end of a wooden block with which the pipe had been plugged. Sometimes the pipe line was of sheet iron and sometimes it was of wood. With heads varying from forty to fifty feet, square wooden pipes were frequently used, these being merely square wooden boxes bolted together with iron rods, if they could be secured, or otherwise the box would be clamped together by means of wood frames, cleats and wedges.

Hurdy gurdy wheels and wood pipe lines of the forms just described were considered good practice in 1854, but as time passed and small quartz mills were erected, it was found that the sphere of usefulness of the hurdy gurdy could be increased to the driving of stamp mills, which it did fairly well when brass nozzles and moderately high heads were used as became the common practice.

*Abstract of a paper read before the Thirtieth Annual Convention of the American Institute of Mining Engineers, San Francisco, September 27, 1899.

1 See *Cassier's Magazine*, Vol. V, pages 109 and 117.

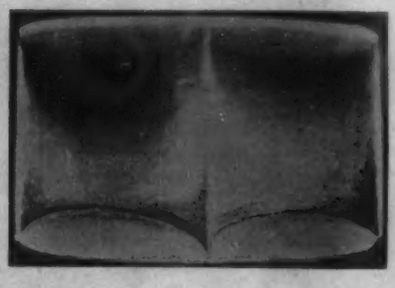
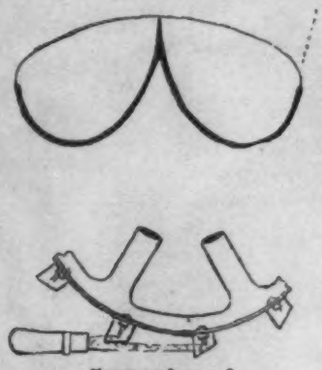


FIGURE 4.

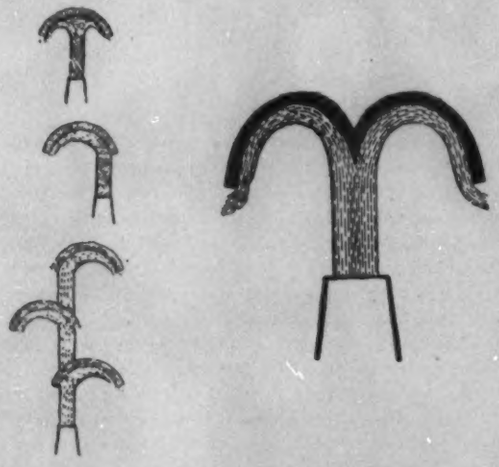


FIGURES 2 AND 3.

FIGURE 5.

THE MOORE BUCKET.—FIGURES 2 AND 3, ORIGINAL SKETCHES; FIGURE 4, FRONT VIEW; FIGURE 5, REAR VIEW.

The question of efficiency was never taken into consideration until hurdy gurdy wheels were applied to the operation of large stamp mills, and then it was found that the hurdy gurdy would not develop the power required to give the mill the proper speed, the cause being attributed to the fact that as the buckets were closed in at each side and on the bottom, the waste water could not discharge itself freely, in consequence of which the buckets would remain full during the greater portion of the time during which they remained in the jet. All additional water directed against the bucket after it was filled, merely slipped over the face of the water already in the bucket, and out into the open air.



L. A. PELTON'S FIGURES 6, 7, 8 AND 9.

The hurdy gurdy was a pure impact wheel, and at that time but little if any thought had been given to the reaction of water as applied to the present forms of tangential wheels.[2] About 1866, the Pacific Iron Works of San Francisco installed a wheel in the Gwin mine in Calaveras county which was the first to introduce reaction.

In 1870, S. N. Knight brought out a new type of bucket which was a marked improvement over all previous forms as was demonstrated by its installation in the Gwin mine in 1872 where it operated a twenty-stamp mill. This wheel was of the true tangential type and its buckets were so shaped that they had both side and inward discharges, while most of the latter types of bucket have mainly side discharges. The stream of water applied to the Knight bucket is of rectilinear cross section. But, to revert to the historical side of the matter, the first Knight wheel was made in 1870 and it presented no radical departure from the present form of Knight wheel. In 1872 a Knight wheel was placed in the Gwin mine to operate a twenty-stamp mill, this wheel being first equipped with buckets having an inward discharge; next, they were changed to those having side discharges, and finally the present form was adopted, which has both inward and side discharges.

In 1873 Nicholas J. Coleman secured a patent[3] on a bucket which contained a central dividing wedge for splitting the stream, thus doing away with dead water in the bucket and bringing out the reactive forces of the stream to the best advantage. Coleman was clearly the first to suggest the divided bucket, but its advantages were not appreciated until others had, perhaps independently, perfected it. In 1874, Joseph Moore, of the Risdon Iron Works, San Francisco, submitted a sketch of a divided bucket to G. Tiscornia, of San Andreas, Calaveras county, and buckets made in accordance therewith, as shown in Figures 2 to 5, were shipped to San Andreas on April 13th, 1874. The records of the Risdon Iron Works substantiate Mr. Moore's claim.

[2] The author gratefully acknowledges his indebtedness to Mr. S. N. Knight, of Sutter Creek, Cal., for most of the information given concerning hurdy gurdy wheels.

[3] U. S. Letters Patent, No. 135,891, February 18, 1873.

L. A. Pelton states that between 1878 and 1880 he tested between thirty and forty different shapes of buckets, and finally noticed that a curved bucket having a jet strike on the side as in Figure 7, instead of in its center (Figure 6), gave marked increase in efficiency, to obviate which he placed the buckets alternately, as in Figure 8, whence it was but a step to combine the two curved buckets into a form which would split the stream as in Figure 9, and thus originated the Pelton bucket.

Prof. F. G. Hesse, of the University of California, was drawn into the controversy by Mr. Pelton in the hope of disproving Mr. Moore's contention, and from his (Hesse's) statement, it appears that between 1865 and 1868 Mr. Moore asked his advice as to the best form of water motor to operate under a high head at a good efficiency, in considering which it occurred to Prof. Hesse that if the separated parts of a form of water wheel then known of, and which is shown in Figure 10, be combined so as to form a single wheel, and one bucket out of every pair of buckets, as in Figure 11, the conditions would be best satisfied. Prof. Hesse states that the drawings for such a bucket were furnished to Mr. Moore presumably between the years mentioned. It seems evident in the light of other facts, however, that Mr. Moore was the first to suggest the generally adopted form of divided bucket, and that the part which Prof. Hesse took is confirmatory of Mr. Moore's contention. In the evolution of the tangential wheel have also figured the names of Biggio[4], Pitchford[5], Donnelly[6], Dodd[7], Watson, Berry[8], Cazin,[9] Tutthill[10], Hug[11], Kale, Ridgway[12], and Bookwalter[13], as well as those of the James Leffell, the Risdon Iron Works[14], and Abner Doble Company[15] with their "cascade," "Risdon" and "ellipsoidal" wheels respectively.

Without entering into a consideration of the features of these types of wheels, it may be said that the ideal bucket would receive the stream in a solid condition and reverse it without breaking; it would discharge the water along natural lines; it would bear such relation to the stream that the plane of the bucket would be perpendicular to its axis and the force exerted by the impact would be equal at whatever angle the plane of the bucket bears to the axis of the jet. The friction between the water and the surface of the bucket should be minimized, ample clearance should be given the buckets to permit free discharge, buckets should be given the longest possible arc of contact with the stream, the face of the buckets should not beat or slap the stream, and buckets should

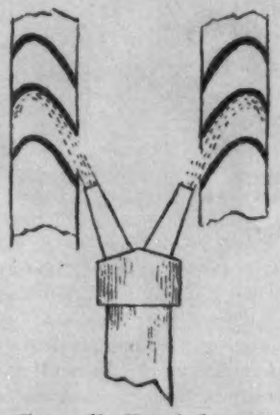


FIGURE 10.—HESSE'S SKETCH.

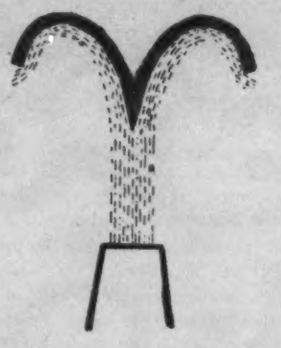


FIGURE 11.—HESSE'S BUCKET.

[4] U. S. Letters Patent, No. 356,977, February 1, 1887.
[5] U. S. Letters Patent, No. 485,477, November 1, 1892.
[6] U. S. Letters Patent, No. 255,259, March 21, 1882.
[7] U. S. Letters Patent, No. 401,484, April 16, 1889, and 454,638, June 23, 1891.
[8] U. S. Letters Patent, No. 493,239, March 14, 1893.
[9] U. S. Letters Patent, No. 578,812, March 16, 1897.
[10] U. S. Letters Patent, No. 534,772, February 26, 1895.
[11] U. S. Letters Patent, Nos. 576,728 and 576,849, February 9, 1897.
[12] U. S. Letters Patent, No. 453,449, June 2, 1891.
[13] U. S. Letters Patent, No. 469,959, March 1, 1892.
[14] U. S. Letters Patent, No. 599,845, January 26, 1897, and 626,568, March 1, 1898.
[15] U. S. Letters Patent, Nos. 619,148 and 619,149, February 7, 1899, and 613,184 September 19, 1899.

enter and leave the stream with the utmost quickness. Moreover, buckets of the most familiar forms split the stream on entering it in two planes; *viz.:* the entering lip splits in the plane transverse to the wheel's rotation, while the dividing wedge in the center of the bucket splits the stream in the direction of the wheel's rotation. This transverse splitting is both unnecessary and undesirable. A bucket that will not split the stream transversely and which will be of such shape as to preserve this perpendicular, is found in the ellipsoidal type which has no entering lip and the shape of which is described from true hydraulic curves.

Substantiation of this will be found in an examination of buckets taken from wheels that have been run by water containing sand, grit or slickens. Under these conditions, the faces of buckets containing entering lips will be found to be badly worn from striking against the jet. Such a wheel, having forty buckets and run at 1000 revolutions per minute, breaks up the jet at the rate of 40,000 times per minute by blows struck by the face of the bucket, causing the wear against the outer surface of the lip, and, what is far more serious, wasting the energy of the stream. The inner side of such a bucket will be found to be seriously eroded from the swirling action of the water in inner corners because the bucket is so formed as to prevent proper discharge. The reason will be clear from an examination of Figure 12. The jet, striking on the inner side of the face of the bucket, glances off the surface at an equal angle, for the "angle of incidence is equal to the angle of refraction." This glancing action occurs at three points

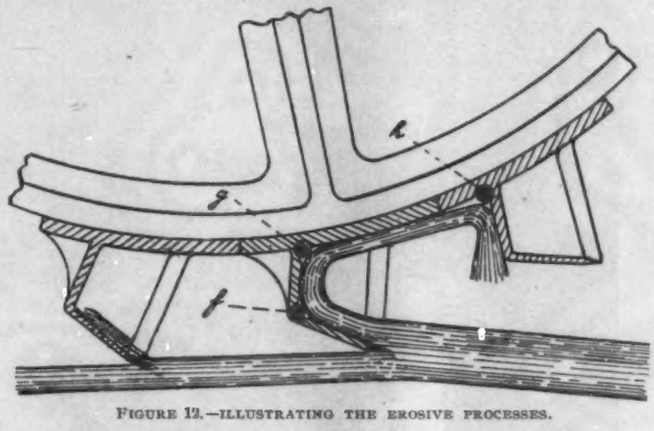
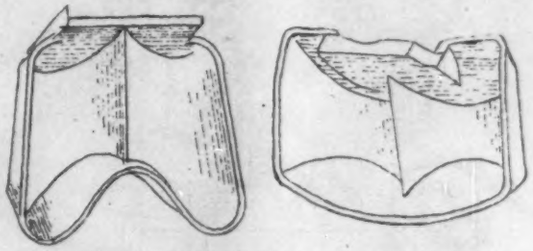


FIGURE 12.—ILLUSTRATING THE EROSIVE PROCESSES.

within the buckets; *viz.:* on its front, bottom and rear faces — all of which is clearly shown by lines of erosion that will be found to have been cut by the sediment within the water. The consequence is inevitable that a swirling or whirlpool action will take place at the corners *f*, *g* and *h*, resulting in great loss in energy and the eventual perforation of the bucket at these points. Buckets made on true hydraulic lines show no pitted erosions, and such wear as occurs is in straight lines and even throughout.

Buckets of more familiar forms are characterized by the broad edge which forms the entering lip, and the jet-splitting wedge placed radially along the center They, therefore, exert a two-fold influence upon the stream; first, the entrance of the bucket into the jet causes the stream to be split by the entering lip in a plane that is axial to the wheel; second, as the portion of the jet which is diverted into the bucket encounters the splitting wedge therein, the water is again divided whence it endeavors to flow in accordance with natural laws, but instead of doing so it is ordinarily forced to pursue the path provided for it. These lipped buckets are therefore pernicious in several respects, for they not only divert the stream from its natural course while the lip is passing through the stream, but they permit the bucket to be drawn into the jet comparatively slowly, whereas it should be done with the nearest approach to instantaneousness that is possible.

Heretofore, makers of tangential wheels have failed to realize that the action of a jet of water on a stationary bucket is altogether different from that which occurs on a moving bucket; hence most wheels have been designed to give maximum impulse and reaction when the base of the bucket is perpendicular to the axis of the stream. The error is a natural one; for the maximum torque which a tangential wheel which is held stationary will exert will be given when the direction of the jet is as stated: perpendicular to the plane of the bucket, which demonstrates that the angle of maximum effort which a jet can exert is fixed at ninety degrees. There are two ways by which this condition may be satisfied, one of which is thoroughly impracticable, while the



FIGURES 13 AND 14.—THE DODD AND PELTON BUCKETS.

second is thoroughly simple and effective. The feathering paddle wheel offers the key to the first solution, for as it always enters the water on the perpendicular, it would sustain the plane of a water wheel bucket at the perpendicular to the axis of the stream during the arc of contact. The execution of this in connection with tangential wheels with their high rotative speeds and centrifugal force, presents mechanical difficulties which preclude all hope of its successful application. The second solution is found deeply veiled in the Berry bucket, the reciprocal of which furnishes the hydraulic curves for the faces of buckets as will give a smooth, even and uniform distribution of forces over practically the entire surface of the bucket regardless of its position in the arc of contact with the stream. Before discussing the ellipsoidal bucket, it will be well to give further consideration to the remaining features of the ideal bucket. The manner in which the jet is brought into contact with the bucket is of paramount importance. All will concede that the stream should enter the bucket in a solid condition, and that, in other words, the stream should be divided or disturbed in the least possible degree. The form of entrance lips are of two classes; namely, straight and in-curved. The great majority of buckets are of the straight-lipped variety, as in the original Pelton, Risdon, Hug, Cazin and other well-known forms. The main examples of the curved-entrance variety of buckets is found in the Dodd wheel and the ellipsoidal bucket, which has no entering lip. I can not but believe that of these two last named buckets the latter is the more efficient for the conclusive reason that the Dodd bucket is so formed that the stream is split before entering the bucket by the in-curved lip, while in the ellipsoidal bucket the solid stream is not split or otherwise interfered with in any manner whatever until after it is within the bucket and reaches the dividing wedge. In fact the only contact on entering the

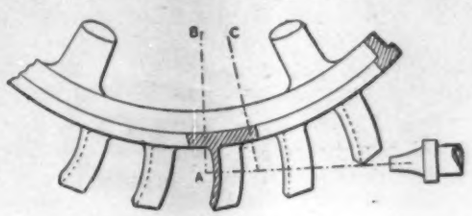
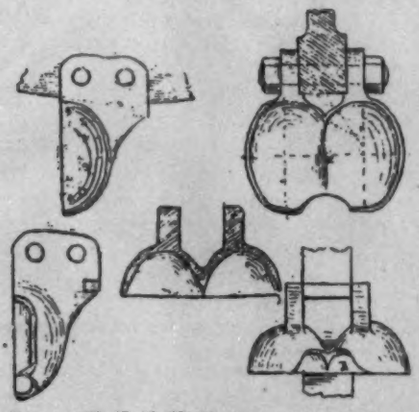


FIGURE 15.—THE BERRY BUCKET.

ellipsoidal bucket into the stream is that with the dividing wedge. A straight-lipped bucket breaks up the stream and deflects it during the transit of the lip; it diverts the stream outwardly because of splitting it as by a wedge having an edge which is axial to the wheel, and thus it splits the stream transversely before the wedge in the bucket has had an opportunity to split it radially to the wheel and reverse the direction of the water. In the ellipsoidal bucket the stream is divided only in the plane in the wheel's rotation, thus dividing the stream in only two equal parts, each of

which flows over the hydraulic curved faces in the bucket. This reverses the direction of flow of the stream without disturbance or shock and avoids the eddy currents that are set up where an end lip is used. Buckets of the entering-lip type first shave off the stream in thin slices, each slice being again divided by the



FIGURES 16, 17, 18, 19, 20.—SECTIONAL VIEWS OF THE ELLIPSOIDAL BUCKET.

central dividing wedge, and this additional disturbance to the stream preventing the smooth flow of the water through the bucket which is essential to high efficiency.

The problem of the resolution of forces of the tangential wheel changes with each and every change in the position of the bucket with reference to the stream. The first thorough appreciation of these variations in forces of which there is authentic record, appears in the Berry patent (1893), Figure 15. The idea which prevailed in the design of the Berry bucket[16] was that the axis of the stream should be tangential to the surface of the bucket at whatever its position within the arc of contact with the stream, to accomplish which, buckets of convex forms, of a carefully calculated curvature were used; but they never saw commercial usage for the reason that the patent went the way of many other inventions and was "shelved" by its owners, perhaps because of the fact that while the axis of the stream, being an imaginary line,

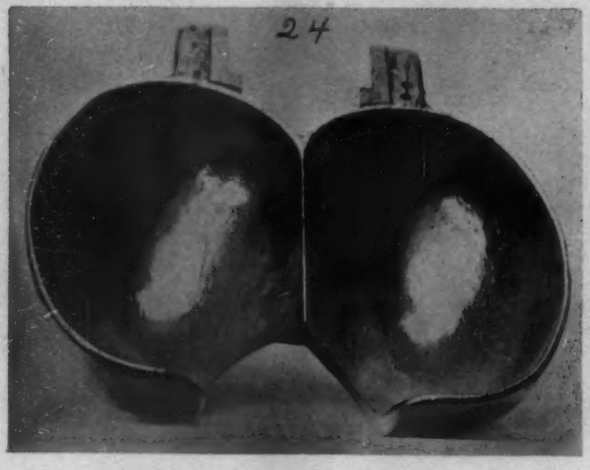


FIGURE 21.—THE ELLIPSOIDAL BUCKET.

may be perpendicular to the tangent of the surface of the Berry bucket, the stream itself, having breadth, and consequently bulk, can never be such.

In the ellipsoidal bucket, the stream is not split transversely; the first and only splitting of the stream is that caused by the radial dividing wedge within the bucket, and the curvature of the bucket is such that the resolution of the forces exerted by the stream are always in lines tangential to the surface of the dividing wedge whatever be its position in the arc of contact with the jet. Thus is the highest possible efficiency in tangential water wheel practice attained.

The writer is therefore constrained to say that the latest and most important change and improvement in tangential water wheel practice since the development of the Coleman and Moore buckets, has been the recent adoption of what may be called hydraulic curves for the faces of the buckets, and in dividing the jet vertically or radially and in one plane only, *after* its entrance within the bucket.

The first of those features has, by some strange oversight, escaped the attention of engineers. For fifty years past it has been a prominent and even essential feature of turbine practice; and indeed in all of the refined type of water wheels wherein the water was reversed in its course over the faces of the buckets, but has not been considered, or at least has not been applied, in tan-

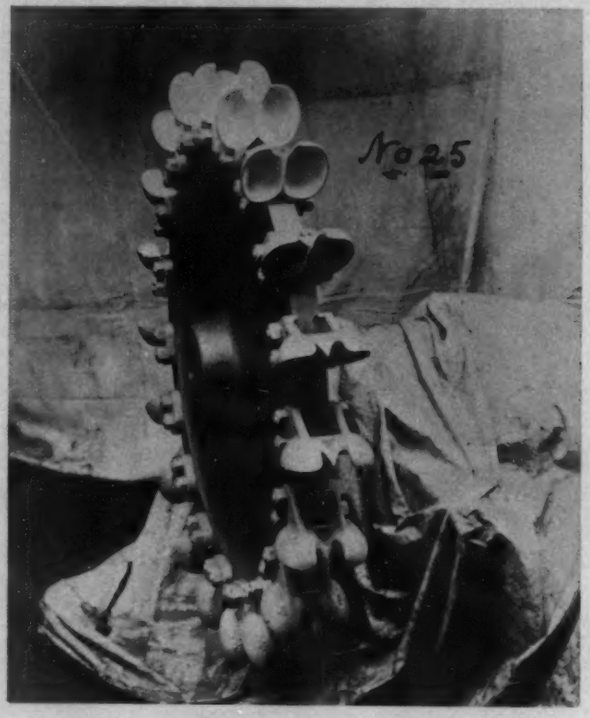


FIGURE 22.—A 1000-HORSEPOWER ELLIPSOIDAL WHEEL.

gential wheel practice until when buckets as shown in the outline drawings, Figures 16 to 20, were adopted for wheels installed for operation in large units under high head. Previously, the faces of the buckets had either been true curves, or developed curves that did not conform to the hydrodynamic conditions demanded. Figure 21 shows an ellipsoidal bucket for a 1000-horsepower wheel, while Figure 22 shows the ellipsoidal bucket as mounted on a finished wheel that is in daily operation under a head of 1300 feet.

The extreme simplicity of the tangential wheel, its low first cost, its very high efficiency — over 80 per cent. — gives it a ready adaptability in the engineering field. Wheels have been made in California in diameters varying from three inches to thirty feet, to work under heads of from 35 to 2100 feet, and under speeds ranging from 65 to 1150 revolutions per minute. Its use is not limited altogether to conditions of high head in nature, as it is eminently adapted for certain classes of work such as in rolling mills or in other instances even where high pressure must be given to the water by modern high duty steam pumping engines. Tangential wheels can be installed in units of any desired capacity; their high efficiency is maintained, irrespective of load, by the use of regulating nozzles; they enable the centralization of the steam plant and prevent losses due to long lines of steam piping; they

[16] See *Cassier's Magazine*, Vol. V, page 125, *et seq.*

occupy but a fraction of the space taken by steam engines; they are started, stopped, reversed or run at any desired speed with the utmost facility; they stand all sorts of abuse and neglect and require practically no attention; they are unaffected by external surrounding conditions, and under proper installation their efficiency is oftentimes as high and sometimes much higher than other systems of power distribution, while the cost of installation and maintenance is far less.

As compared with the turbine, the first cost of the tangential wheel, when considering heads of over fifty feet, is very much less; its cost of maintenance being but a fraction of that of the turbine. In addition to the fact that its initial efficiency is superior to that of the turbine, it also maintains its original high efficiency throughout its life, whereas with the turbine the efficiency is constantly decreasing as the wheel wears in the casing, which allows the water to pass by instead of through the wheel. The variation in design permissible in turbine practice is quite limited as regards speed and power owing to the excessive cost of turbines of large diameter, whereas with the tangential wheel it permits of a very wide and free scope to the designer.

Transmission

ROTARIES IN THE HARTFORD PLANT.*

BY W. L. ROBB.

OF the three 60-cycle alternators in use in the Hartford transmission plant, one is operated by steam and the other two are operated by water power at a distance of eleven miles from the first. These generators have been continuously run in parallel during the last three years and no difficulty whatever has been found in this method of operation.

The operation of the rotary transformers has not been so simple a matter. At the outset there was great excess of sparking at the commutator. This sparking was soon found to depend very largely on the variety of brushes used. It was found that a very soft carbon brush gave the best results, but without special treatment of the brushes, sparking, although diminished, is still excessive. The method of treating the brushes suggested by our superintendent was tried and found effective. The carbon brushes are first raised to a red heat, and then plunged in ordinary lubricating oil and allowed to cool. When brushes treated in this manner were used all vicious sparking was stopped, and in this particular the transformers ran as smoothly as direct-current generators of the best type. At the outset, in operating the rotaries considerable difficulty was met with in preventing pumping at times when the engines were supplying power to the system. This pumping could be traced to the variation in the angular speed of the engines, and when the water power alone was supplying the power there was little, if any, pumping. It was found that this tendency to pumping could be checked by varying the field excitation of the rotary transformers or by temporarily throwing a portion of the load on the storage battery. Only once in the past three years has the pumping been such as to cause any serious interruption. The switchboard at the substation was originally arranged to give the greatest possible flexibility in operation. Both rotaries could be run in multiple with the battery, or both rotaries could be run in multiple, feeding into the line, and the excess of current used to charge the battery; or one rotary could be run on the line and the second rotary used to charge the battery independently. This last method of operation was found impracticable, although at times desirable. Under this condition the pumping would immediately begin, and it necessitated giving up this method of operation. Notwithstanding the above-mentioned difficulties, when a year ago it was decided to increase the direct-current machinery we had gained sufficient confidence in the rotary system of 60 cycles to purchase a 400-kilowatt rotary rather than a direct-current generator.

The third rotary, when tested, proved to be free from any tendency toward pumping, either when operated from the steam plant or from the water power, and was in every way as nearly perfect as a machine could be. However, when thrown on the line with the two older rotaries, they immediately began pumping, and it was found impossible to run the three rotaries together. The pumping in a rotary system seems to be cumulative; it is very easy to stop it if the proper remedy is applied as soon as the first tendency to pump is noticed. If allowed to go on it quickly gets beyond control. The impossibility of running the three rotaries together necessitated some change. The Westinghouse company's engineers maintained that the corrective device could be applied with equal effect to any one of the three rotaries. Copper strips were attached to the pole-pieces of the 400-kilowatt rotary. This rotary, of itself, was all right, but the developing of any tendency of the system towards pumping was entirely overcome by means of these copper strips. The system now works perfectly, whether operated by steam or water power. Even under the trying conditions of running the rotaries under different voltages, two feeding directly into the line and the third independently charging the battery, no trouble with pumping is experienced. In all other respects the rotary transformers have been all that could be asked for; they have run practically continuously night and day for nearly three years, and have had practically no repairs, the commutators simply being turned down once or twice a year.

[The "pumping" of rotary converters or synchronous motors, and an effective means of accomplishing its prevention are discussed in a United States patent issued to B. J. Lamme on May 30th, wherein it is stated that the immediate cause of all such irregular action may be primarily due to irregular speed of the generator, to difference in form of the electromotive force waves of the generator and of the motor or rotary converter, etc. The immediate cause of the pumping lies largely in the distortion of the field of the motor or transformer when its armature has been forced for an instant to run at a speed either slightly greater or slightly less than the normal or synchronous speed. This distortion of the field of the machines may be explained as follows: If the armature of either an alternating or direct-current generator or motor is carrying current, its ampere-turns have a cross-magnetizing effect on the pole tips or edges which tends to straighten one edge and weaken the other. The resultant field is thus shifted either forward or backward, depending on the action of the current. In the case of a synchronous motor at no load, there should be very little armature current, and therefore a small distortion of the field. If the speed is suddenly changed, however, the motor armature will take considerable current, the resulting field will be shifted, and the armature will tend to move into a new position. In doing this, the field distortion, wave form, etc., are somewhat changed. The armature takes a current in the opposite direction for an instant, so that if in the first case, it receives current as a motor, it begins to deliver power for an instant. This distorts the field in the opposite direction, and the armature tends to swing the other way. If in the one case it was accelerating in speed, in the other it begins to drop in speed. Thus the armature may get into a sort of oscillation relative to the normal or synchronous speed, and this oscillation or "pumping" may be very small for a time, and gradually increase until it is so violent that the machine is thrown out of step with the system. The armature current due to the pumping is in turn a leading and lagging current, which tends alternately to strengthen and weaken the field magnetism. The field current will also oscillate with the pumping of the armature. In a rotary converter when an oscillation is started, incoming current represents more ampere turns than the current delivered, which will produce distortion as in a synchronous motor, and as the field alternately strengthens and weakens, the electromotive force varies, and the transformer pumps.

The patent specifications point out a method, known to be that

*Abstract of a paper read before the Twenty-second Convention of the National Electric Light Association, New York, May 23-25, 1899.

A description of the Hartford transmission appears in *The Journal of Electricity* for November, 1898.

of the Westinghouse Electric and Manufacturing Company, as installed in the Hartford and several rotary plants, for the prevention of this alternate distortion, which is done by placing copper shields or plates over or around the pole tips or edges, and copper rings around the ends of the pole pieces. If these shields and rings are of sufficient section and properly placed, the alternate distortion of the field at the tips or edges of the pole pieces will set up secondary currents in the shields and rings, which will oppose the distortion and neutralize its effect. Thus, when employed in connection with a rotary converter, they will, by neutralizing the magnetizing and demagnetizing effects of the armature currents, assist the machine to deliver a smooth direct current; and further, if the electromotive force waves of the generator and rotary converter are alike in form, the closed rings and shields acting as a secondary to the magnetizing and demagnetizing effects of the armature current, will tend to prevent injurious effects by reason of the flow of current between the two machines. The device illustrated in the patent consists of a flat strip of copper placed axially on each edge of the pole face, and a heavy ring of copper about each polar projection.—ED.]

TRANSFORMER RATIOS EASILY DETERMINED.

A SIMPLE method of determining ratio of transformation in which errors of observation are eliminated, is due to J. R. Bibbins.* It requires the use of a single alternating-current voltmeter reading from zero to 150 volts, a source of alternating current (100 volts), and preferably a Pohls commutator,

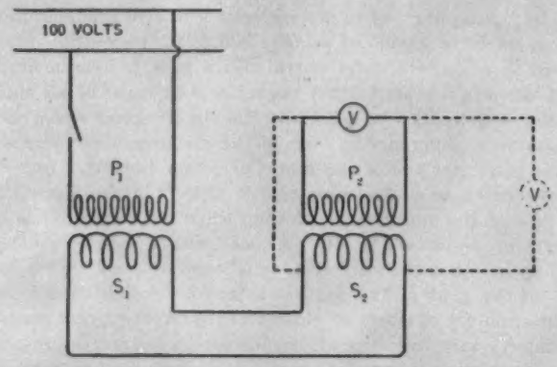


FIGURE 1.—DIAGRAM OF CONNECTIONS, WITHOUT COMMUTATOR.

although the method may be applied without the commutator as the connections may be changed by hand. If the voltage of the alternating-current source is fairly constant, accurate results may be obtained without the use of a Pohls commutator, but if there is considerable fluctuation in voltage, its use will insure much more reliable results, as the voltmeter may then be transferred instantly

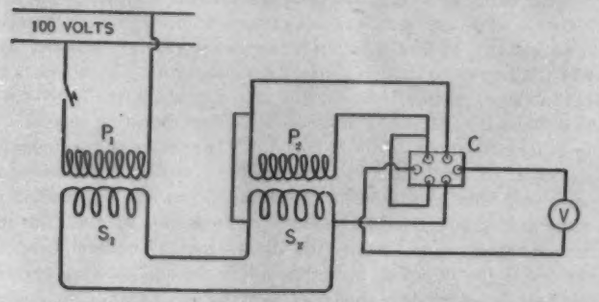
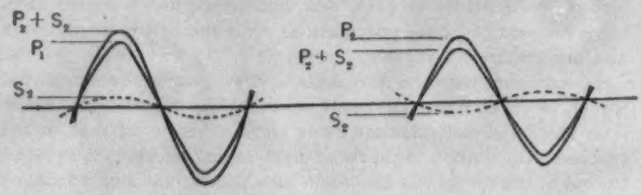


FIGURE 2.—DIAGRAM OF CONNECTIONS, WITH COMMUTATOR.

from one circuit to another. The method has been used at the University of Michigan with great success.

Referring to Figures 1 and 2, T_1 and T_2 are two transformers of approximately the same ratio of transformation, of which the ratio of T_2 is desired. Connect the two secondaries, S_1 and S_2, together, and the primary P_1 to the 100-volt mains or other source of alternating current with a switch-in circuit for convenience. First read the voltage at the terminals of P_2 (as indicated by the continuous lines in Figure 1), which will presumably be about 100 volts. Second, connect two terminals of P_2 and S_2, as indicated



FIGURES 3 AND 4.—TRANSFORMER PHASE RELATIONS.

by the dotted portion of Figure 1. This should be either about 110 or 90 volts, depending upon which terminals are joined together. Assuming the values:

$$P_1 = 100 \text{ volts}$$
$$P_2 = 102.6 \text{ "}$$
$$P_2 + S_2 = 111.25 \text{ "}$$
$$P_2 - S_2 = 93.95 \text{ "}$$

Then ratio of $T_2 =$

$$\frac{P_2}{(P_2 + S_2) - P_2} = \frac{102.6}{111.25 - 102.6} = \frac{102.6}{8.65} = \frac{1}{11.861}$$

or ratio of transformation $= 11.861$. (1)

Or, again:

$$\frac{P_2}{P_2 - (P_2 - S_2)} = \frac{102.6}{102.6 - 93.95} = \frac{102.6}{8.65} = \frac{1}{11.861}$$

or ratio of transformation $= 11.861$. (2)

The identity of these results obtained in the above cases is explained thus: It is well known that at no load the primary and secondary electromotive forces of a transformer are displaced in phase 180°. If then S_2 is superposed upon P_2, as in Figure 1, whether S_2 will be subtracted or added to P_2 will depend on whether S_2 is in phase with P_2, as in Figure 3, or 180° behind it, as in Figure 4. That this feature is altogether immaterial is evident by observing that the dotted curve S_2 is derived in either figure by subtracting ordinates, and as only the numerical value of S_2 is required, the phase relations may be entirely disregarded.

The ratio of transformation of T_1 may be found in the same manner as that of T_2 by a simple interchange of position and connections.

CURRENT IN TWO AND THREE PHASE LINES.*

DETERMINING the current in the wires of two and three phase lines for a given number of kilowatts or horsepower, with a given voltage and power factor, is a problem requiring considerable calculation from the proper formula, all of which can be very readily replaced by the accompanying scales. Of these, Figure 1 gives the values for two-phase lines, and by multiplying by two gives the current strength for the same conditions on single-phase lines, while Figure 2 gives the current for three-phase lines. The formulas from which they were drawn are given with them.

The directions for their use are as follows: To find the current per phase for any output at any voltage, look up the vertical line corresponding to that output in kilowatts as determined by the horizontal scale running along the base of the intersecting squares. Follow this vertical line up to its intersection with the horizontal line corresponding to the voltage of the circuit, and the current strength in amperes will be found at the end of the diagonal current line intersecting that point. For example, upon the two-phase chart 50 kilowatts at 1100 volts shows approximately 22½ amperes per phase. In case the circuit is single-phase the number of amperes for this load at this voltage would be 45. If no diagonal line passes through the point of intersection the value of the current may be found by interpolation between the diagonal lines next above and below. For example, 70 kilowatts at 900 volts

Electrical World and Engineer, Vol. XXXIV, page 376.

*From the *American Electrician*, Vol. XI, page 391.

shows a current strength midway between 37½ and 40 amperes, or about 38¾ amperes. By noting the position of the decimal point any current at any voltage may be determined. For example, to determine the current at 2200 volts for a given load, the current at 220 volts may be read off from the chart and divided by 10; similarly, to determine the current for 500 kilowatts, 50 kilowatts may be applied to the chart and the result multiplied by 10.

If the load is given in horsepower instead of kilowatts, it may be followed up vertically from the scale on the lowest radial line. For example, 80 horsepower at 600 volts gives 50 amperes.

The other radii are for use in case the power factor is less than unity. In this case the kilowatt line should be followed down vertically to its intersection with the radius representing the power factor of the circuit, and the circle intersecting this point should be traced around to the vertical and carried up into the scale of volts and kilowatts. For example, 70 kilowatts with a power factor of 80 per cent., shows an apparent load of 88 kilowatts, which may be followed up to, let us say, 1100 volts, giving 40 amperes.

By combining these various methods a given number of horsepower with a given power factor may be reduced to current. For example, 106 horsepower, followed up vertically, shows 80 kilowatts, which, with an 80 per cent. power factor, shows 100 apparent kilowatts and a current dependent upon the voltage as above pointed out. The chart is also reversible, a given number of amperes at a given voltage being readily reducible to kilowatts and horsepower if the power factor is known. For example, 70 amperes at 300 volts is evidently 43 kilowatts, or 56 horsepower, if it is non-inductive. If it has a power factor of 90 per cent., the same

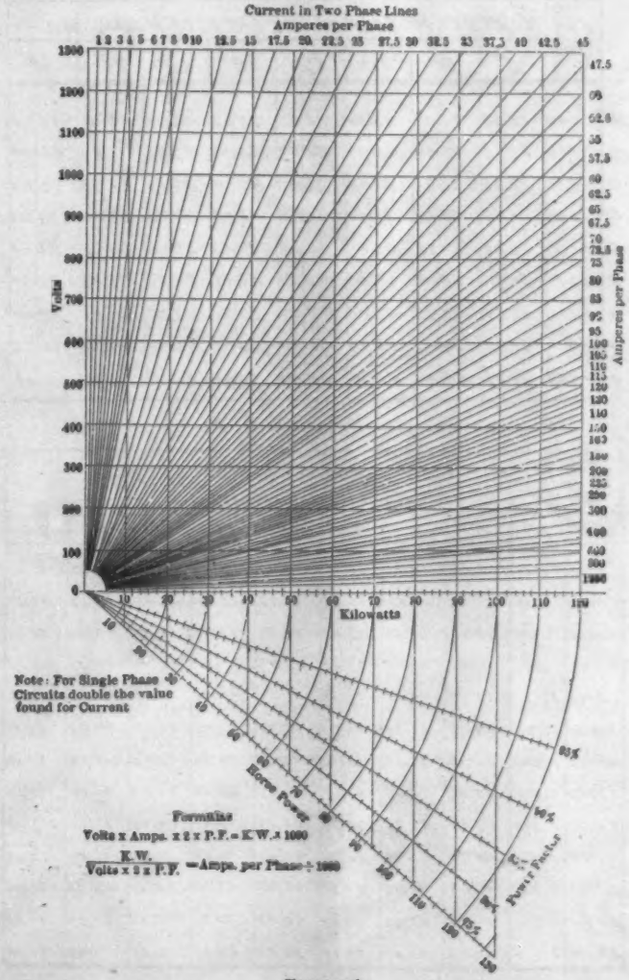

Current in Two Phase Lines
Amperes per Phase
Volts
Amperes per Phase
Kilowatts
Horse Power
Power Factor
Note: For Single Phase or Circuits double the value found for Current
Formulas
Volts x Amps. x 2 x P.F. = K.W. x 1000
K.W. / Volts x 2 x P.F. = Amps. per Phase ÷ 1000

FIGURE 1.

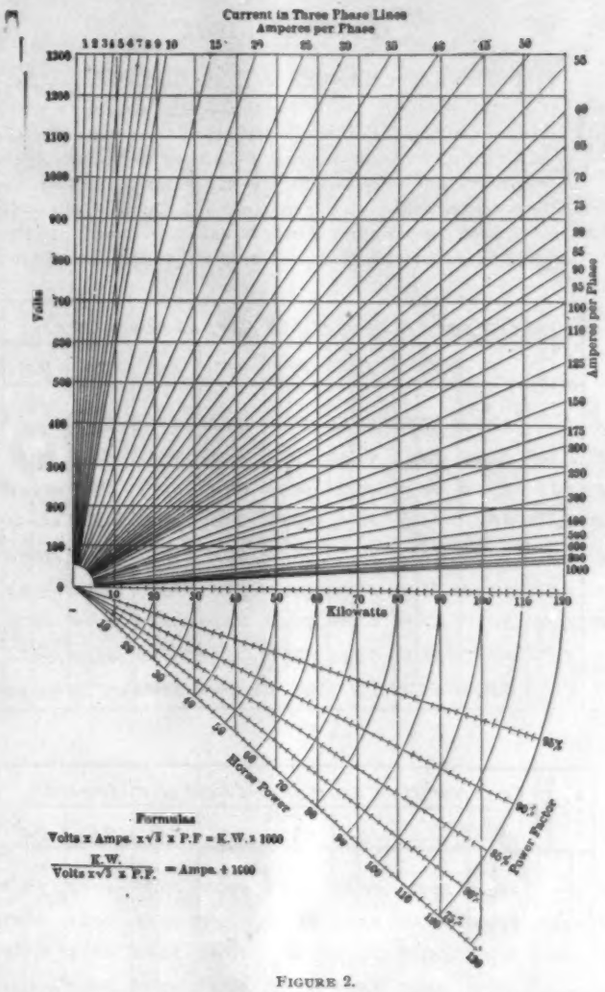

Current in Three Phase Lines
Amperes per Phase
Volts
Amperes per Phase
Kilowatts
Horse Power
Power Factor
Formulas
Volts x Amps. x √3 x P.F = K.W. x 1000
K.W. / Volts x √3 x P.F. = Amps. ÷ 1000

FIGURE 2.

number of amperes at the same voltage becomes 39 kilowatts or 52 horsepower. The same methods are exactly applicable to the scale of three-phase systems.

The lower diagonal or radial lines may be used to represent the efficiency of a motor in place of the power factor; for example, a 90 kilowatt motor having an efficiency of 90 per cent. would require 100 kilowatts to drive it, and the current required can be found as above.

These charts were drawn up by Stephen Q. Hayes, to whom indebtedness for their publication is acknowledged.

LOAD FACTORS AND GENERATION COSTS.

THE practical value of the load factor has been tested out during the operation of the three-phase system in Brooklyn, N. Y. At one time 2000-horsepower was shifted to and from the Union station from two of the large direct-current stations in such a way for each of two days the total generated kilowatts of the Union station remained exactly the same; but the load-factor during one of the days was 25 per cent. and during the other 80 per cent. Careful record was then kept of the cost of generation during the 24 hours of these two days in the Union station. It was found that when the load-factor of the station was 80 per cent., the cost was decreased 70 per cent. over what it was when the load factor was 25 per cent., the total kilowatt-hours of each of the two days being exactly the same.

"'Industrial Gas' promises to be a very interesting and valuable contribution to gas literature; send me your numbers for April, May and June containing it," writes Lewis A. Hicks, C. E., of Bakersfield, Cal., in a recent letter to the JOURNAL.

Distribution

SERVICE CHARGES AT A GLANCE.

QUICK and accurate means for the determination of power service charges for different periods of time each day and at different rates, are of great assistance to all managers, engineers and solicitors for electric power companies, and herewith are given, through the courtesy of C. N. Beal, six tables from which such service charges may be ascertained with celerity.

Electric power service is charged for on either the horsepower-hour, or on the kilowatt-hour basis; and, when yearly costs are considered, the annual service is for 313 or 365 days according to whether the service continues through Sunday or for but six days in the week. Seldom are conditions of installation and operation so favorable that electric power can be delivered at a rate of one cent per kilowatt-hour, although it is very rarely possible that conditions would warrant a rate as low as one-half cent per horsepower-hour, or its equivalent rate of .7602 cents per kilowatt-hour. The minimum rate considered under these tables is, therefore, the one last given, which appears in tables *E* and *F*. In all tables the rate advances by eighths and the range of each table is suf-

	Costs per K.W. Hour		Cost per K.W. Year of 365 Days of Hours viz:-							
			8	9	10	12	15	18	21	24
			$							
A	1		29.20	32.85	36.50	43.80	54.75	65.70	76.65	87.60
B	1	125	32.85	36.96	41.06	49.27	61.59	73.91	86.22	98.55
C	1	25	36.50	41.07	45.62	54.75	68.43	82.12	95.81	109.50
D	1	375	40.15	45.17	50.18	60.22	75.27	90.33	105.38	120.43
E	1	5	43.80	49.28	54.75	65.70	82.12	98.55	114.97	131.40
F	1	625	47.45	53.39	59.31	71.17	88.96	106.77	124.53	142.38
G	1	75	51.10	57.50	63.97	76.65	95.80	114.98	134.14	153.30
H	1	875	54.75	61.60	68.43	82.12	102.64	123.19	143.71	164.25
J	2		58.40	65.70	73.00	87.60	109.48	131.40	153.28	175.20

TABLE A.

	Costs per H.P. Hour		Cost per H.P. Year of 365 Days of Hours viz:-							
			8	9	10	12	15	18	21	24
			$							
A		746	21.78	24.51	27.23	32.68	40.84	49.01	57.18	65.35
B		839	24.50	27.57	30.63	36.77	45.95	55.14	64.33	73.52
C		933	27.23	30.64	34.04	40.85	51.06	61.28	71.48	81.69
D	1	025	29.95	33.70	37.44	44.94	56.16	67.39	78.62	89.86
E	1	119	32.67	36.77	40.85	49.02	61.26	73.52	85.77	98.02
F	1	21	35.39	39.83	44.25	53.11	66.37	79.64	92.91	106.19
G	1	305	38.12	42.89	47.65	57.19	71.47	85.77	100.06	114.36
H	1	4	40.84	45.96	51.06	61.28	76.58	91.89	107.21	122.53
J	1	492	43.56	49.02	54.46	65.36	81.68	98.02	114.36	130.70

TABLE B.

	Costs per K.W. Hour		Cost per K.W. Year of 313 Days of Hours viz:-							
			8	9	10	12	15	18	21	24
A	1		25.04	28.17	31.30	37.56	46.95	56.34	65.73	75.12
B	1	125	28.17	31.68	35.21	42.26	52.82	63.38	73.95	84.51
C	1	25	31.30	35.21	39.13	46.95	58.69	70.43	82.16	93.90
D	1	375	34.43	38.73	43.04	51.65	64.56	77.48	90.38	103.29
E	1	5	37.56	42.26	46.95	56.34	70.43	84.51	98.60	112.68
F	1	625	40.68	45.78	50.86	61.04	76.29	91.53	106.81	122.07
G	1	75	43.82	49.30	54.78	65.73	82.16	98.60	115.03	131.46
H	1	875	46.95	52.82	58.69	70.43	88.03	105.64	123.24	140.85
J	2		50.08	56.34	62.60	75.12	93.90	112.68	131.46	150.24

TABLE C.

	Costs per H.P. Hour		Cost per H.P. Year of 313 Days of Hours, viz:-							
			8	9	10	12	15	18	21	24
A		746	18.68	21.02	23.35	28.02	35.02	42.03	49.03	56.04
B		839	21.02	23.65	26.27	31.52	39.40	47.28	55.16	63.04
C		933	23.36	26.28	29.19	35.03	43.78	52.54	61.29	70.05
D	1	025	25.69	28.90	32.11	38.53	48.16	57.79	67.42	77.06
E	1	119	28.02	31.53	35.03	42.03	52.53	63.05	73.55	84.06
F	1	21	30.36	34.16	37.94	45.53	56.91	68.30	79.68	91.07
G	1	305	32.69	36.79	40.86	49.04	61.29	73.55	85.81	98.07
H	1	4	35.03	39.41	43.78	52.54	65.66	78.81	91.93	105.08
J	1	492	37.36	42.04	46.70	56.04	70.07	84.08	98.06	112.08

TABLE D.

Cost in Cents per Hour		Cost per H.P. Year of 365 Days. Days Length in hours being, viz:							
K.W.	H.P.	8	9	10	12	15	18	21	24
		$							
.6702	.500	14.60	16.43	18.25	21.90	27.38	32.85	38.33	43.80
.8378	.625	18.25	20.53	22.81	27.38	34.22	41.06	47.91	54.75
1.0054	.750	21.90	24.64	27.38	32.85	41.06	49.28	57.49	65.70
1.1730	.875	25.55	28.74	31.94	38.33	47.91	57.49	67.07	76.65
1.3406	1.	29.20	32.85	36.50	43.80	54.75	65.70	76.65	87.60
1.5082	1.125	32.85	36.96	41.06	49.28	61.59	73.91	86.23	98.55
1.6758	1.250	36.50	41.06	45.63	54.75	68.44	82.13	95.81	109.50
1.8432	1.375	40.15	45.17	50.19	60.23	75.28	90.34	105.38	120.45
2.0107	1.500	43.80	49.27	54.75	65.70	81.72	98.55	114.97	131.40
2.1783	1.625	47.45	53.38	59.31	71.18	88.97	106.76	124.53	142.35
2.3458	1.750	51.10	57.49	63.88	76.65	95.81	114.98	134.14	153.30
2.5134	1.875	54.75	61.59	68.44	82.13	102.65	123.19	143.72	164.25
2.6810	2.	58.40	65.70	73.00	87.60	109.50	131.40	153.30	175.20

TABLE E.

Cost in Cents per Hour		Cost per H.P. Year of 313 Days. Days Length being in hours, viz:							
K.W.	H.P.	8	9	10	12	15	18	21	24
		$							
.6702	.500	12.52	14.09	15.65	18.78	23.48	28.17	32.87	37.56
.8378	.625	15.65	17.61	19.56	23.48	29.34	35.21	41.08	46.95
1.0054	.750	18.78	21.13	23.48	28.17	35.21	42.26	49.30	56.34
1.1729	.875	21.91	24.65	27.39	32.87	41.08	49.30	57.52	65.73
1.3405	1.	25.04	28.17	31.30	37.56	46.95	56.34	65.73	75.12
1.5080	1.125	28.17	31.69	35.21	42.26	52.82	63.38	74.95	84.51
1.6756	1.250	31.30	35.21	39.13	46.95	58.69	70.43	82.16	93.90
1.8432	1.375	34.43	38.73	43.04	51.65	64.56	77.48	90.38	103.29
2.0107	1.500	37.56	42.26	46.95	56.34	70.43	84.52	98.60	112.68
2.1783	1.625	40.69	45.78	50.86	61.03	76.29	91.56	106.81	122.07
2.3458	1.750	43.82	49.30	54.78	65.73	82.16	98.60	115.03	131.46
2.5134	1.875	46.95	52.82	58.69	70.43	88.03	105.64	123.24	140.85
2.6810	2.	50.08	56.34	62.60	75.12	93.90	112.68	131.46	150.24

TABLE F.

ficient to enable the result obtained from it to be applied as a factor in the determination of costs of service at rates other than those which appear in the tables. The length of days in hours is given under the cost-per-year heading, and these hours indicate the time of service per day.

It is obvious that the tables take no cognizance of load factor or of any sliding scale of rates graduating the costs down with increased consumption. They apply to the delivery of electric service on a straight kilowatt-hour basis. These and similar points are quite irrelevant to the tables for the reason that due consideration should be given to matters pertaining to load factors and consumption before quoting the rate in each specific case.

The tables are so simple that a detailed explanation of their mode of operation is believed to be unnecessary.

RECTIFICATION OF ALTERNATING CURRENTS.

VARIOUS arrangements of circuits which may be adopted in connection with alternate-current rectifiers having no moving parts—such, for example, as the electrolytic rectifier of Graetz and Pollak, which will be described later—are discussed by L. Kallir in a German electrical contemporary.* The cases considered by Kallir are shown in the annexed sketches, wherein the arrow affixed to each rectifier indicates the direction in which the current is allowed to flow, the rectifier itself being indicated by a circle containing an arrow.

The arrangement shown in Figure 1 is not to be recommended, as the current varies a great deal, reaching a zero value during each period.

In the opinion of the author, the connections of Figure 2 might be used with advantage for exciting the fields of an alternator, as the pulsations in the direct current therefrom are extremely slight.

Figure 3 shows an arrangement due to Graetz and Pollak, the characteristic feature of which is the utilization of *both* half-waves

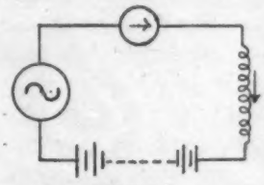


FIGURE 1.

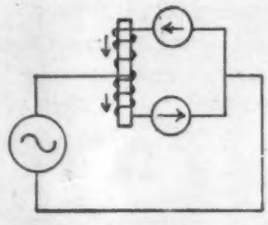


FIGURE 2.

of the alternating current. In this case, and with a reasonable amount of inductance in the circuit, the pulsations are also slight.

Lastly, Figure 4 shows an arrangement adapted to three-phase circuit; the direct current from which may be rendered remarkably constant.

The Graetz and Pollak electrolytic rectifier, heretofore referred to, is based on the fact that when an anode of aluminum is employed in an electrolytic cell and the electrolyte is such that oxygen will be generated at this anode, the current passing will be reduced to an extraordinarily high degree. This is probably due to the formation of a low conducting film of oxide on the anode which increases the resistance of the circuit, and also to a kind of condenser action between the electrode and the liquid, or a di-electric polarization, as opposed to the ordinary electrolytic polarization. This latter view is based on the fact that each cell has a quite definite counter electromotive force of 22 volts, so that currents of lower potential do not pass through the cell. On reversing the current, however, the back electromotive force is less than one volt. The cathode may be of carbon, platinum, or any other usable metal except aluminum, and the electrolyte may be of any of the alum solutions (such as sodium-alum and potassium-alum solutions) or of dilute acids which generate oxygen on electrolysis.

*See *Science Abstracts*, No. 207, 1898, and No. 1090, 1899.

If an alternating current be sent through a number of these cells arranged in series, the number being such that the polarization at the anode is greater than, or at least equal to, the potential of the alternating current, it follows that the positive impulse of the alternating current, in which the aluminum is the anode, is not allowed to pass through, while the negative impulse will pass through. In this manner an interrupted direct current is obtained of one-half the strength of the original alternating current, but the loss of one-half of its energy is not, however, involved in this.

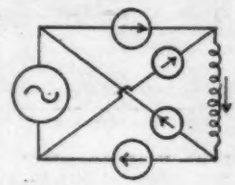


FIGURE 3.

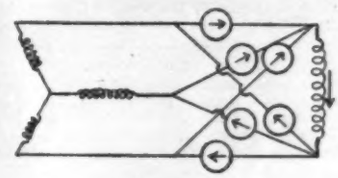


FIGURE 4.

By arranging another battery, having a similar number of cells but with its poles reversed, in parallel with the battery first mentioned, across the alternator terminals, the other half of the alternating current may be obtained as direct current, and the result is that a pulsating direct current then flows around the two branched circuits; that is, the positive current in one and the negative current in the other.

In a modified arrangement, a pair of oppositely-connected batteries are connected at each terminal of the alternating potential difference, and the other or opposite terminals of like batteries are connected together by conductors from which a direct current can be taken. By using sufficiently large cells so as to bring down the resistance as much as possible, a maximum energy efficiency of 95 per cent. can be obtained.

PURITY OF ALUMINUM.

MOISSAN, in referring to Ditte's experiments on an alloy of aluminum with about three per cent. of copper,* lays stress on the great influence exerted by the purity of aluminum on its resistance to corrosion, and on the importance of excluding the possibility of electrolytic action due to the contact of some other metal with aluminum.

Recent progress in the electro-metallurgy of aluminum has been accompanied by a notable improvement in the quality of the commercial metal produced, as is shown by the following table due to Minet.†

Composition of Commercial Aluminum.	In 1890.	In 1893.	In 1897.
	Per Cent.	Per Cent.	Per Cent.
Silicon	0.90	0.25	0.02
Iron	0.40	0.40	0.12
Aluminum	98.70	99.35	99.86

Since 1897 these traces of other metals in aluminum have been removed and the metal in its commercial form is now chemically pure.

ROTATIVE DIRECTION OF SYNCHRONOUS MOTORS.

Single-phase synchronous motors will run in either direction as started, but the rotative direction of polyphase synchronous motors is reversed under the same rules as apply in polyphase induction motors, which are given on page 40 of the August issue.

Chas. F. Scott, chief electrician of the Westinghouse Electric and Manufacturing Company, writes: "I want to congratulate you on the evident prosperity and the advancement which the JOURNAL is making as is indicated by the enlargement of its title. The full and exhaustive way in which you take up a thing makes the articles in the JOURNAL of especial interest and value."

Science Abstracts, 1899, No. 1532.

†*Ibid.*, No. 1553.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS

Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.

Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII OCTOBER, 1899 NUMBER 4

For Table of Contents see Page X.

EDITORIAL.

MUNICIPAL OWNERSHIP THERE AND HERE.

San Francisco and Oakland are sister cities, geographically, socially and commercially. The first has all that goes to make a metropolis frenzied in mad commercialism; the other is a charming suburb of all the beauty and sobriety that the term implies. The population of the one aspires to at least the half-million mark, while that of the other numbers close to one hundred thousand, but each is a city well worthy of the name. Each is also distraught with its own local issues. Oakland has, or has had itself involved in throes of excitement over matters of domestic import ranging in consequence from a determination of the fate of an anti-cigarette ordinance to the perennial agitation concerning its water frontage—all, however, of no greater interest to the world at large than are the interchanges of maternal sympathies and secrets across a back yard fence. But the nation has no greater interest in the politics of New York City than has the state of California in the affairs of San Francisco. Here are centered the largest commercial interests of the State, the densest population, and, not least, here are found most astute, subtle and even knavish of politicians—sage and sleepless devotees to Mammon that they are! More than this, the mystic shrines of this occult sect are currently believed to be not far removed from the general offices of the corporations which dispense to the patient public various utilities in the way of water, street-railway transportation, gas and electricity.

Political matters have no place in these columns. A presentation of the influences which they may exert for good or for evil upon the light, heat and power industry, or a discussion of the influences which the policy of quasi-public corporations may exert for good or for evil upon the potentialities of municipal or governmental exactions and regulations may not, however, be out of place. It has been said times without number that the emissaries of local corporations are the most potent of all political corruptionists, and no sincere denial of the charge has hitherto been made. Gas, street railway, electric and water companies, as a class, are, then, under arraignment as exercising pernicious and malicious influences. Just how far, locally, do facts warrant the accusations, just what are the situations in this respect in Oakland and San Francisco, and to what extent are these municipalities warranted in forebearing the exercise of their legal prerogatives in the acquirement of public commodities?

These are broad questions when applied to San Francisco—too broad, in fact, to receive consideration at this time—but Oakland presents an instance warranting an absolute denial of the charge, for, as will be shown, the conduct of its lighting monopoly at least has been exemplary.

In Oakland the attitude of the lighting company toward the public has been that of fairness even to liberality, of honesty even to philanthropy, and of public-spiritedness even to self-sacrifice. The fairness of the Oakland Gas, Light and Heat Company is evidenced by its voluntary reduction in rates with each improvement or new process it acquires; its honesty is attested by the fact that while costs of production of electric energy are no less than the ordinary figures, yet the rate for street lighting in Oakland is but about half of that charged in the near-by city—a difference so strikingly apparent that interested electrical concerns do not possess the effrontery to list the respective costs in their publications of schedules of prices paid for street lighting in the United States. Lastly, the public-spiritedness of the Oakland monopoly has been proved on many occasions, one only of which need be cited: In April last a serious deficit in city finances confronted the City Council of Oakland, and the city employees from mayor to the catcher of vagrant dogs accepted three-quarters pay for the remainder of the fiscal year to tide over the extremity. Still the treasury showed a deficit. The manager of the gas and electric company straightway appeared before the council and volunteered to execute the contract it held for lighting the city for a sum less by $5743 than the amount which the contract called for. A disclaimer to that amount under the contract was duly filed, "and," continued the manager in his address before the council, "we are prepared to go further. We will, if you find your deficit increase beyond present estimates, consent to further reductions after the same manner."

The lighting monopoly of Oakland has, then, never made itself liable to the charge of corrupting politics. More than this, so long as its present policy is preserved, not only would municipal ownership be an absurdity, but successful competition will be an exceedingly difficult, if not impossible, task.

Municipal ownership has no place in Oakland for the reasons stated. In San Francisco it may and undoubtedly will be well for the city to fortify its future welfare against

corporate greed by venturing upon the experiment of municipal ownership to the extent of owning its own pole lines and such circuits as are necessary for the lighting of the streets, municipal buildings and public places. Such ownership will insure legitimate and plentiful competition for all time; *it will make a net reduction in the cost of street lighting by nearly, if not quite, fifty per cent.;* it will eliminate all the monstrous element of perplexity which attends the administration of engineering affairs by unfitted political roustabouts; and it will forever make it impossible for San Francisco to again feel chagrined in the knowledge that for years and years, had it but known it, the *open sesame* to fifty per cent. rates has been the mere existence of *a competitive circuit to the point of service.* San Francisco found that the cost of lighting the City Hall was reduced just one-half for no other reason than that the mains of the Mutual company had at last reached that building. San Francisco will find that the cost of its street lighting will be reduced a similar amount by no other exercise of the right of municipal ownership than the building of the pole line aforesaid. And this is for the simple reason that no new company, however strong, can afford to build these city lighting circuits on the gauzy prospect of securing the city contract for a single year.

Here then, is San Francisco's golden opportunity for municipal ownership.

Under its new charter, if wisely administered, San Francisco may find amelioration from the pernicious influences that have ever been exerted toward perpetuating the present conditions and prices under which the contracts for lighting its streets and public buildings are awarded. The JOURNAL will always be found staunch in its advocacy of fair returns upon honest capitalization. It will ever contest exorbitant rates as earnestly as it will decry ruinous competition, and it will find no dearth of words to express its denunciation of any course that may be taken toward throttling legitimate competition to the detriment both of the public weal and of the general welfare of the industries the JOURNAL represents.

IMPOUND THE STATE'S FLOOD WATERS!

What is the matter with some of the electrical journals of the American metropolis? One of them, in discussing the effect of water power development on the industries of California, observes:

> At present there are eleven enterprises in California which are utilizing the formerly wasted water power of the mountain streams for the production of electrical energy, the most important being the plant at Folsom, where 45,000 horsepower is generated and transmitted twenty-four miles to Sacramento; the San Gabriel Electric Power Company's plant which delivers 6000 horsepower to Los Angeles, a distance of twenty-seven miles; and the San Joaquin Electric Company's plant by means of which several thousand horsepower of electrical energy is transmitted to Fresno and neighboring towns.

Then again, another New York electrical journal says:

> One hundred and fifty thousand horsepower of energy is to be supplied to the city of San Francisco from Blue Lakes, 150 miles away. The total output of the plant has been contracted for in advance by San Francisco parties, customers of the Standard Electric Company of that city. The system adopted is the Stanley, of Pittsfield, Mass., and the work of installing will proceed as rapidly as possible, the contract for the apparatus having been entered into a few days ago.

Truly, we must go from home to get news. We who are on the ground and who are reputed to be familiar with things as they be, are disposed to believe that one cipher too many has been added to the statement alleging the capacity of the Folsom plant; also that if still another cipher be dropped from the corrected figure, close to the truth will then be had as to the twenty-four-hour load which the Folsom plant delivered last summer. The fact is that the Folsom station was then running only by night upon water conserved during the day; the steam auxiliary plant at the sub-station in Sacramento was being run to full capacity by day and partly during the night, while the Yuba Electric Power Company delivered 1000 continuous horsepower, day and night, to the Sacramento sub-station. The plant of the Capital Gas Company, which has been acquired by the owners of the Folsom-Sacramento transmission, is carrying the arc lighting load of the city. As to San Gabriel, the transmission plant has an installation of only 2200 horsepower in water wheels, and during the drouth it delivered less than one-fourth of that amount of power for the simple reason that, as with Folsom, Fresno and other transmissions, it was short of water. And poor Fresno! It shut off its power service and street lights, and its newly-appointed receiver would doubtless be glad to know that he could rely on having several hundred horsepower, to say nothing of the several thousand horsepower which the plant is reputed to be delivering—incidentally from three 340-kilowatt generators! In the Blue Lakes-San Francisco transmission, too, the capacity has been multiplied by ten, for the initial installation will be in the neighborhood of 15,000 horsepower, and not 150,000 horsepower as stated.

We will not arraign our esteemed metropolitan contemporaries, for surely the enchantment of distance has placed them under magic spell. But capital and the engineering world want fact, and only fact—and fact they shall ever have in these columns.

Then do not misunderstand the motive which underlies the publication of the cold, hard truth concerning the water supplies of some of the electric transmissions of California. For more than two years now the Golden State has suffered from drouth. Its mountains were snowless; many of its rivers were dry or nearly so; its great valleys were parched, except in favored localities, and its mining and transmission interests were, in the main, badly crippled from lack of water. Some transmissions, notably those on the Yubas and on the Kern and Kaweah rivers, have been favored with supplies of water which have been phenomenal, considering the seasons, but others have found that the only alternative from virtual shut-down has been the erection and operation of auxiliary steam plants.

And all this drouth and crippling of industries occurs

in a country where, even in periods of drouth, the flood gates of heaven open at times and the dry beds of the rivers become for a day filled to the brink with raging torrents which oftentimes wash out levees and inundate hundreds of square miles of farming lands. Then in a day or two more, the river beds are almost as dry again as ever, for the mad rivers have spent their fury in the sea. This is not a fanciful picture, for should a tithe of the waters that rush down the canyons of the Sierras even during periods of so-called drouth be impounded in mountain storage reservoirs, all the transmission and mining plants which the coming generation may install would never know want of water.

A remedy for this most unfortunate condition—for the deep mining and electrical transmission interests of the State find their main difficulty in operation to lie in the unreliability of water supply—is found in the suggestion implied at the end of the preceding paragraph; namely: IMPOUND THE FLOOD WATERS OF THE STATE!

It is gratifying to know that the seriousness of the problem is at last fully realized by many of the most prominent business men of California, and that this recognition, which has long lain dormant, has now assumed tangible form in the organization of the California State Association for the Storage of Flood Waters, a committee of which is now preparing an address to the people of the State setting forth the objects of the Association and of the convention of delegates which is to be held in San Francisco on November 14th. Among the members of this committee appears the name of Dr. Thomas Addison, manager of the San Francisco office of the General Electric Company, and president of the Sacramento Electric Railway and Gas Company.

Some estimate of the necessity for attaining the objects of the Association may be had from the recent remarks of Mr. W. C. Ralston, vice-president of the California State Miners' Association, to the effect that the drouth during the winter of 1897-98 had at the most conservative estimate caused a loss of $7,000,000 to the miners alone, and all the way from $25,000,000 to $30,000,000 to the farmers and orchardists of the State.

MEASURING DYNAMO EFFICIENCIES.

To the subscriber who asks the JOURNAL to describe a simple method for measuring dynamo efficiencies, it may be stated that the determination of the efficiency of direct-current dynamos and of alternators having good regulation, involves the consideration of three elements of loss; *viz.*: iron loss, copper losses and friction losses. Of these losses, those due to iron and friction are practically constant under all conditions of load, while the copper losses increase directly with the load according to the square of the current (C^2R) in field and armature, separately considered. These factors of the total loss may be easily determined by driving the dynamo from an electric motor preferably through direct connection, and measuring the net power applied to the motor by means of an indicating wattmeter, the term "net power" signifying the difference between the watts required to drive the motor with and without the load.

The iron loss of the fields is inconsequential. The iron loss of the armature core is found in the difference between the net wattage used in driving the motor (1) when the armature of the dynamo is at normal speed and the field charge gives normal voltage from the armature; and (2) when the armature is at normal speed with no field charge.

The friction and windage loss is expressed in the net watts consumed by the motor in driving the armature at normal speed without field charge.

The copper losses in armature and field coils are expressed in the watts derived by multiplying the square of the current by the resistance (C^2R), care being taken to calculate the resistance of the copper at the running temperature.

The sum of these losses is the total loss in watts, and the output of the dynamo at any load, divided by such output plus the total loss at that load, gives the commercial efficiency of the dynamo.

Gas

INDUSTRIAL GAS.—VII.

BY FRANK H. BATES.

COLLECTION OF SAMPLES. The method to adopt in collecting a gas sample is dependent upon the conditions under which one is operating. The first point to be observed is to use such means as will give a sample representing the average gas. Oftentimes in the gases to be sampled there exist currents whose composition vary considerably, this being

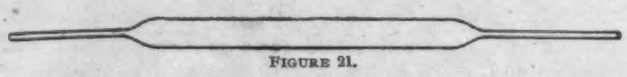


FIGURE 21.

especially true in the case of chemical processes and furnace gases. In such instances some ingenuity must be exercised to meet the special conditions.

For the retention of a gas sample, the collection tube shown in Figure 21 will serve. The ends are made quite long and drawn down to about two millimeters ($\frac{1}{16}$-inch) internal diameter. They should be of about 200 cubic centimeters capacity. It will be found very convenient for transportation to have a box, provided with separate

FIGURE 22.

compartments, to hold about a dozen of these tubes. To take a sample it is simply necessary to connect, by a short rubber tube, at one end to the gas supply, allowing the gas to flow through (the gas being under pressure) till certain that all air has been expelled and that only pure gas remains; then almost stopping the flow to relieve the

tube of pressure, seal near the end by holding a lighted candle to it, or by means of an improvised blowpipe made by pointing and nearly closing the end of a glass tube, and then bending near the point, cutting off at a convenient length.

The collection tube will serve for a number of samples before becoming so short as to make it necessary to weld on new ends.

A somewhat handier tube is shown in Figure 22, having glass stop-cocks, which obviates the necessity of sealing by heat. Although there is but little liability to leakage with these tubes when the ground glass stop-cocks fit properly and are kept well greased, yet the writer has made it a practice, when obliged to retain the sample some time before making the analyses, to cover all joints and the open ends with sealing wax, which renders leakage impossible. A case of these collection tubes is shown in Figure 23. Instead of water for the confining liquid, mercury is often used when the previous saturation of the water is inconvenient or for other reasons.

It is sometimes desirable to obtain a sample of a gas passing through a conduit of some kind, which may represent the average gas for a certain period of time. For such purpose the apparatus illustrated by Figure 24 is well suited. The tanks A and B are constructed of galvanized iron, and measure some 12 inches in diameter and 18 inches in length, one being slightly longer than the other. Bottoms and tops of the tanks should be slightly curved downwards and upwards respectively, to render it possible to secure complete drainage. At about

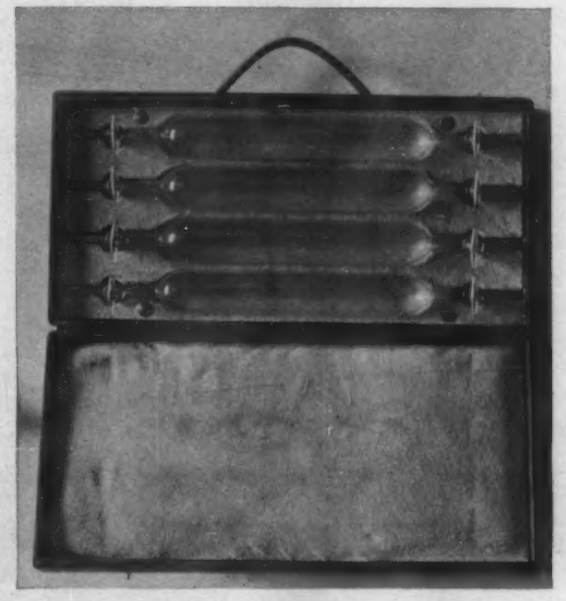


FIGURE 23.

the center of both top and bottom is inserted a ¼-inch gas pipe nipple, the joint being strongly soldered, on which are screwed pet-cocks for the tops and pipe connections to the outside for the bottoms, there being a rim sufficient to raise the tank above the piping. Pet-cocks are put on the lower pipes at a convenient distance from the side. On the tops there are also auxiliary nipples with pet-cocks attached, to allow of rapid filling.

Operation. The upper (larger) tank is first filled with water and then connected to the gas source by suitable means, while on a shelf below, and with its auxiliary pet-cock connected by rubber tubing to the outlet from

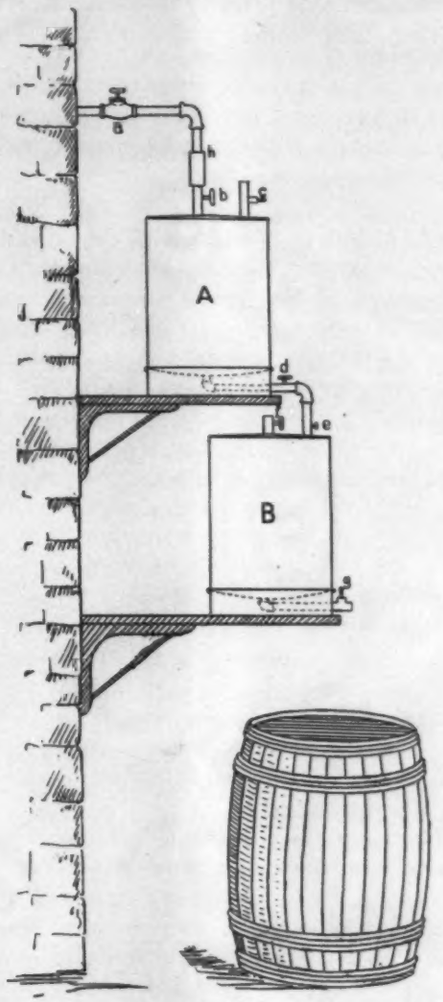


FIGURE 24.

the upper tank, is placed the smaller one. By turning on the globe valve *a* (on the pipe leading to the gas source) and opening pet-cocks *b*, *d*, *e* and *f*, and with pet-cocks *c* and *g* closed, allow the water to run from the tank A into tank B, displacing the air from the latter and causing it to issue from the open pet-cock *f*. As the water recedes from the tank A, a partial vacuum is created which causes the gas to rush in. The receding water, mingling with the inrushing gas, becomes thoroughly saturated and is used to fill the lower tank B. On the overflow of water from the pet-cock of the tank B, pet-cocks *f* and *e* are closed, and the tank is disconnected from the upper one (which is removed), and connected up to the gas source by attaching the rubber tube *h* to the pet-cock *f*. With a long rubber tube attached to the outlet pet-cock *g*, to serve as a drain to the waste barrel, open the pet-cocks *f* and *g*, causing the water to run from *g* and draw in the gas through *f*. By adjusting these pet-cocks, the time

taken to fill the tank may be lengthened or shortened, so that an average sample of a run of a certain duration may be obtained. The previous saturation of the water used prevents the washing out of the soluble constituents of the gas.

The kind of piping to use for running into the furnace or holder will depend upon the temperature and nature of the gases. With a high temperature iron tubes with ample water-jacketing should be employed.* Porcelain, glass or platinum tubes may also be used. Where the gases are strongly acid and the time occupied in making the collection is long, only glass tubes should be employed; they will not be affected by temperatures within 600° C. At temperatures lower than 300° C., lead piping will be found serviceable owing to its great flexibility. Since vulcanized rubber tends to absorb the gases, rubber tubing of any length should be avoided.

In a single flue, way or conduit from which the sample is being drawn, there are often found currents of some strength and of quite different composition, necessitating, therefore, the use of several branches of piping to penetrate equally all parts and thus afford a fair average. Where the current in the flue way is strong, a suction pump or siphon may be employed to advantage.

For collecting gases from mines, etc., the form of tank shown in Figure 24 may also be used. For this purpose fill with water and place in an upright position where it is desired to sample the gas. By opening both lower and upper pet-cocks cause the gas to replace the water. As soon as the tank empties of water, close all pet-cocks enclosing the sample.

For packing used in making tight joints, asbestos is probably the best, although, under certain conditions, putty, plaster of Paris, or wet waste may be used.

MEASUREMENT OF GASES.

Correction for Temperature, Pressure and Vapor Tension.

Owing to the fact that the volume of a gas varies with change of pressure and temperature, it is necessary to reduce volumes measured under different conditions to some set standard in order that a true comparison may be arrived at. Universal custom has determined this standard as 760 millimeters (29.92158 inches) of mercury for pressure, and 0° C. (32° F.), for temperature; hence by reducing to these conditions, gases of similar composition will always be of equal mass or weight per unit of volume or of equal volume per unit of mass or weight. With this understanding, we may speak of one liter of a certain gas as always having the same mass or weight, and likewise of one gram as always having the same volume, knowing that under like conditions of pressure and temperature there will exist a constant relation between volume and mass.

The pressure acting upon a gas is generally measured in millimeters or inches of mercury: that is, in terms of the height of a column of mercury which it sustains; thus the atmospheric pressure is read from a barometer as so many millimeters or inches of mercury.

In determining the volume of a gas, therefore, it is necessary to consider the conditions under which it is measured. If in an open vessel or in a vessel over a liquid, as mercury or water, in which the level of the liquid is the same inside as it is outside the vessel, then a reading of the barometer, giving the atmospheric pressure, likewise gives the pressure acting upon the gas.

To measure a gas under atmospheric pressure it is only necessary therefore, to confine it in a vessel over a liquid by means of a level tube, and adjust the tube so as to bring the level of the liquid both inside the vessel and in the level tube to the same height, for should the level of the liquid within the vessel be higher than in the tube, the gas will be under diminished pressure, and if, on the other hand, it is lower than in the tube, it will be under a pressure greater than atmospheric, due to the weight of the column of liquid above its level. In Figure 25, if mercury be used for the confining liquid in a level-tube A′ open to the atmosphere, and a measuring burette A closed at the upper end by a pinch-cock, then it is evident that with the levels of the mercury at *a′* and *a* in the level-tube and measuring burette respectively, the gas enclosed in the latter above the mercury is not exerting as great a pressure as is the atmosphere on the liquid at the open end of the level-tube where the level is the lowest. The pressure upon the gas is equal in this case to the atmospheric less 15 millimeters, the distance between the levels, which equals, with an atmospheric pressure of 760 millimeters, 745 millimeters of mercury as actual pressure.

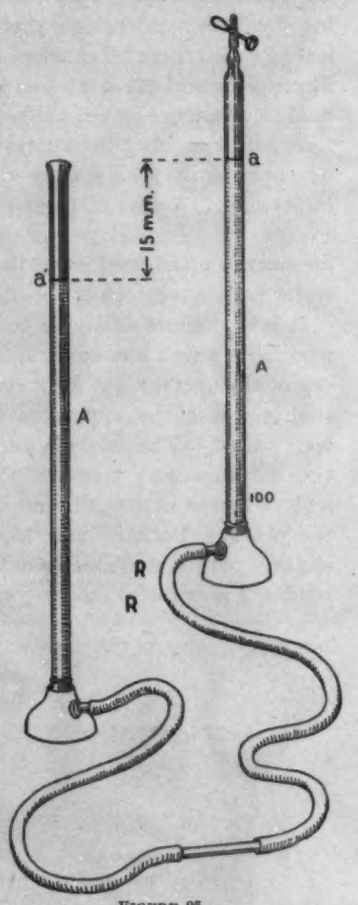


FIGURE 25.

Were the case reversed, that is, were the level *a* 15 millimeters lower than the level *a′*, then the pressure on the gas would equal 760 + 15, or 775 millimeters of mercury.

If water is employed as the confining liquid instead of mercury, it will be necessary to determine the pressure in terms of mercury in order to make use of the barometer and standard conditions. Mercury has a specific gravity of 13.6; that is, the weight of a given volume of water is but $1/13.6$ part of the weight of an equal volume of mer-

*Iron piping, if raised to a temperature of redness, may alter the gas composition, since the oxygen of the iron oxide (iron rust) will combine with the unsatisfied carbon monoxide to form carbon dioxide.

cury. In the foregoing example, had the liquid been water, with the same pressure acting upon the gas, there would have been a difference of level of about 204 millimeters of water, which, divided by 13.6 would give the 15 millimeters of mercury.

Influence of Pressure on Volume. What is known as Boyle's law states that *the volume of a perfect gas varies inversely as the pressure it supports;* that is, the greater the pressure the less the volume. The following example will serve to illustrate this:

A volume of ethylene, C_2H_4, measures two liters under a pressure of 750 millimeters of mercury. What would its volume be under standard conditions of pressure, temperature being neglected?

Standard pressure is 760 millimeters of mercury; consequently we are to determine the volume under an increased pressure, which, by the law of Boyle, will give us a smaller volume. Thus:

760 mm. : 750 mm. :: 2 litres : X (the required volume)

$$\text{or, } 2 \times \frac{750}{760} = X; \text{ or, } X = 1.9 \text{ liters;}$$

that is, the volume under standard conditions of pressure will be 1.9 liters. Conversely:

A volume of ethylene, C_2H_4, measures 1.9 liters under a pressure of 760 millimeters of mercury. What would its volume be under a pressure of 750 millimeters, temperature being neglected?

It is here required to ascertain what the volume of a gas, measured under standard conditions of pressure, would be under a given decreased pressure, which, by the law, will give a greater volume. Thus:

750 mm. : 760 mm. :: 1.9 (liters) : X (required volume)

$$\text{or, } 1.9 \times \frac{760}{750} = X; \text{ or, } X = 2 \text{ liters.}$$

The above operations may be stated more briefly in the following rule:

Multiply the volume actually measured by a fraction whose numerator and denominator will be the absolute pressures, the greater of which will be the denominator or numerator according as the volume is to be decreased or increased, which may be seen by an inspection of the problem and an understanding of Boyle's law.

Influence of Temperature on Volume. Actual experiment has proven that all gases have the same coefficient of expansion by heat. In the centigrade scale the coefficient of expansion per degree is 0.003665, or, expressed in fractional form, $1/273$; that is, the pressure being constant, the volume of a perfect gas increases $1/273$ of its volume at 0° C., for every increase in temperature of 1° C., and in Fahrenheit units 0.002036, or $1/491.2$ of its volume at 32° F., for every increase of 1° F. Likewise it decreases for each negative degree.

It follows, then, that the volume at

1° C. = vol. at 0° C. + $\frac{1}{273}$ (vol. at 0° C.) = $\frac{274}{273}$ (vol. at 0° C.)

2° C. = vol. at 0° C. + $\frac{2}{273}$ (vol. at 0° C.) = $\frac{275}{273}$ (vol. at 0° C.)

3° C. = vol. at 0° C. + $\frac{3}{273}$ (vol. at 0° C.) = $\frac{276}{273}$ (vol. at 0° C.)

t° C. = vol. at 0° C. + $\frac{t}{273}$ (vol. at 0° C.) = $\frac{273 \text{ plus } t}{273}$ (vol. at 0° C.)

and the volume at

− 1° C. = vol. at 0° C. − $\frac{1}{273}$ (vol. at 0° C.) = $\frac{272}{273}$ (vol. at 0° C.)

− 2° C. = vol. at 0° C. − $\frac{2}{273}$ (vol. at 0° C.) = $\frac{271}{273}$ (vol. at 0° C.)

− 3° C. = vol. at 0° C. − $\frac{3}{273}$ (vol. at 0° C.) − $\frac{270}{273}$ (vol. at 0° C.)

and at

− 273° = vol. at 0° C − $\frac{273}{273}$ (vol. at 0° C.) = $\frac{0}{273}$ (vol. at 0° C.)

that is, at − 273°, by the law, the gas would entirely disappear or be of no volume, which would be impossible. To account for this apparent discrepancy in the law governing the effect of temperature on perfect gases, we find that as gases approach the temperature of liquification, their properties change from those of a perfect gas and thus they deviate from the law. In order to facilitate computation, however, the temperature of −273° C. is considered as absolute zero. To obtain absolute temperature, therefore, *add 273° to the readings of the Centigrade thermometer, or 459.2° (= 491.2 − 32)—generally taken as 460°—to the readings of the Fahrenheit thermometer.*

From the foregoing it is readily seen that if a volume of gas measured 273 cubic centimeters at 0° C., (which is 273° C. absolute temperature), and was raised one degree, bringing the absolute temperature to 274° C., the volume would be increased $1/273$ of the volume at 0° C., or the volume would become 273 + 1 = 274 cubic centimeters; and similarly, if raised 5° C., the volume would become 273 + 5 = 278 cubic centimeters. We may therefore restate the law, known as that of Charles, as follows:

The volume of a gas varies directly as its absolute temperature; that is, the greater the temperature, the greater the volume, and the less the temperature, the less the volume.

The following example will serve to illustrate the use of this law:

A volume of ethylene, C_2H_4, measures two liters at a temperature of 21° C. (69.8° F.). What would the volume be under standard conditions of temperature, pressure being neglected?

Standard temperature is 0° C.; consequently we are to determine the volume under decreased temperature, which by the above law, will give a decreased volume. Thus:

Reducing all temperatures to absolute

21° C. = 273 + 21 = 294° C. absolute

0° C. = 273° C. absolute; then,

294° C. : 273° C. :: 2 (liters) : X (required volume)

$$\text{or, } 2 \times \frac{273}{274} = X; \text{ or, } X = 1.8 \text{ liters;}$$

that is, the volume under standard conditions of temperature will be 1.8 liters. Conversely:

A volume of ethylene, C_2H_4, measures 1.8 liters at a temperature of 0° C., what would the volume be under a temperature of 21° C., pressure being neglected?

It is here required to ascertain what the volume of a gas, measured under standard conditions of temperature, would be at a given increased pressure, which by the law, will give an increased volume. Thus:

Reducing all temperatures to absolute

0° C. = 273° C. absolute

21° C. = 273 + 21 = 294° C. absolute; then,

273° C. : 294° C. :: 1.8 (liters) : X (required volume)

$$1.8 \times \frac{294}{273} = X;\ \text{or, } X = 2 \text{ liters};$$

that is, the volume at a temperature of 21° C., will be two liters.

As in the case of pressure, operations may be shortened by the following rule:

Multiply the volume actually measured by a fraction whose numerator and denominator will be absolute temperatures, the greater of which will be the denominator or numerator, according as whether the volume is to be decreased or increased, which may be seen by a simple inspection of the problem and understanding of Charles' law.

The application of the laws for both pressure and temperature may be combined in one operation. Taking the example:

A volume of ethylene, C_2H_4, measures two liters under a pressure of 750 millimeters of mercury and at a temperature of 21° C., what will be the volume under standard conditions of pressure and temperature?

Pressure measured under = 750 millimeters
Standard pressure = 760 millimeters
Temperature measured under = 21° C. = 273 + 21 = 294° C., absolute.
Standard temperature = 0° C. = 273° C.

As the pressure is to be increased, its effect will be to diminish the volume. As the temperature is to be decreased, its effect will be to diminish the volume also, consequently we have

$$2 \times \frac{750}{790} \times \frac{273}{294} = X;\ \text{or, } X = 1.83 \text{ liters.}$$

(Continuation in next number.)

Telegraphy

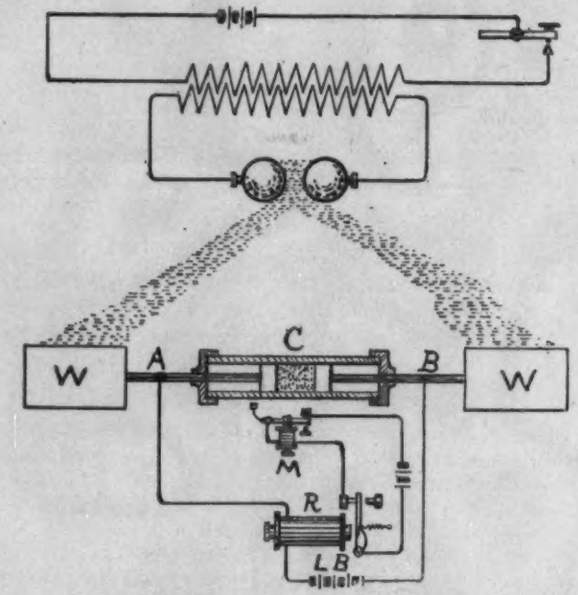
THE PRINCIPLE OF WIRELESS TELEGRAPHY.*

BY WILLIS H. JONES.

MARCONI'S system of wireless telegraphy finds its value in the application of the knowledge that an electrical discharge in the vicinity of iron filings will enormously decrease the ohmic resistance of the filings; that this decreased resistance will prevail as long as the resulting wave disturbance is maintained, and that the filings will resume their former abnormally high resistance upon slightly tapping or jarring the vessel in which they are contained. This means that an electrical wave will enable us to alternately place a high and a low resistance in a local circuit containing an ordinary relay and sounder, without actually removing or substituting any portion of the wire connections. If a tube of iron filings is made to form a part of the circuit which contains the relay, the latter will remain open when the high resistance obtains, because the current flowing will not be strong enough to magnetize the iron core. But when the incoming wave reduces the resistance by setting the small particles of iron filings closely together in regular order, the resulting increment of current sufficiently energizes the magnet to attract the armature, thereby closing the relay. The relay is, therefore, actuated very much after the manner of a neutral quadruplex relay; viz., by an increment of current.

It follows, then, that the Morse alphabet may be recorded on the relay by regulating the duration of length of the wave-making discharge at a distant point so that it will correspond with a dot or a dash. The mechanical construction of the receiving instrument, which is very simple indeed, is shown in the lower portion of the accompanying cut, while the sending apparatus is merely a large induction coil with a key in the primary circuit. The receiver, or coherer, as it is called, consists of a glass tube partially filled with iron filings. Two copper wires, *A* and *B*, are inserted in the tube from opposite ends and make metallic contact with the filings.

The local battery, *L B*, it will be seen, is short-circuited through the filings *via* the two wires *A* and *B*. The filings, therefore, form a part of the loop connecting the Morse relay. Now the small particles of iron within the tube, when arranged in the irregular manner in which they settle when promiscuously poured into the receptacle, introduce so much resistance into the circuit that what little current does circulate in the loop is insufficient to close the relay. But when the waves of ether from a distant point reach the sympathetically attuned metallic plates *W* and *W*[1], they impinge upon the plates, which action causes each separate particle of the filings in the tube to arrange itself in a regular position that shall be uniform with all other particles. The effect of this rearrangement of position is to enormously decrease the resistance* between *A* and *B*. As the remainder of the metallic circuit contains comparatively little resistance, the total obstruction to the energy of the battery is too small to prevent the current from closing the relay, hence the signal will be recorded on a sounder (not shown in the diagram) in the usual way.



After the signal has been made, that is, after the filings have been set in the regular order described, the Morse relay would remain permanently closed unless some means were devised for opening it preparatory to other incoming waves. Fortunately, a slight tap or jar of the tube will instantly destroy the uniform arrangement of the filings and again restore the high resistance between *A* and *B*. This high resistance will, of course, again decrease the strength of the current in the metallic circuit and practically demagnetize the relay, which immediately opens. In the lower portion of the diagram, the manner in which this end is attained is shown: *M* is an ordinary vibratory magnet or buzzer

*From *The Telegraph Age*, Vol. XXII, No. 4, page 67.

*In 1899 *Science Abstracts* No. 106, is given a digest of a paper by E. Dorn, on materials for coherers, appearing in *Wied. Annalen*, and which states that the noble metals—platinum, gold, and silver—give practically no coherer action. Iron gives good results, especially after a short exposure to air. Copper, immediately after filing, shows no change of resistance. After five hours a slight coherer action is observed, and in three weeks the resistance may rise to 300,000 ohms, which falls to 10 ohms under the influence of electric radiation, and rises to 187,000 ohms on concussion. Neither exhaustion nor heating have any influence on a tube containing aluminum filings. In tubes containing nickel, iron, copper or zinc, heating leads to a diminution of the resistance, which in zinc is probably due to sublimation.—ED.

controlled by the contact points of the relay *R*. A little hammer is attached to the armature of the buzzer in such a position that each down stroke of the armature of the buzzer causes the hammer to strike the glass tube a fraction of a second after the contact points of the relay close.

To summarize, wireless telegraphy is attained:

1. By setting ether in motion by means of the disruptive spark of the induction coil.

2. By catching the resultant waves of ether, which possess certain frequency or rapidity of motion, by means of a metallic plate sympathetically attuned to receive them and no others.

3. By reducing and restoring the high resistance of the iron filings in the coherer.

4. By regulating the duration of the wave impulses to correspond with the length of the Morse alphabet by means of a key in the primary circuit of an induction coil.

MOTOR-GENERATORS VS. GRAVITY BATTERIES.

MOTOR-DYNAMOS and dynamotors have become of great importance for furnishing all kinds of electric currents, without other generating machinery, in places where electric light circuits or other ordinary sources of electric power are available, their compactness and high efficiency making it practicable to use electric currents for a great variety of purposes, heretofore thought to be out of reach. The various applications already made are constantly suggesting new uses. The simplicity of an electrically-driven dynamo over one driven by belting has brought motor-dynamos into extensive use, even where shafting was available, while their economy in cost and space occupied, as well as their advantage in cleanliness when displacing chemical batteries for the operation of telegraph lines and for other work, is enormous.

The smallest size of dynamotor, occupying a space of about eight inches cube and having an output of $\frac{1}{12}$ horsepower, will displace about 800 cells of bluestone battery occupying a space of about ten feet cube. The Western Union Telegraph Company's estimate of $1.00 per cell per year as the cost of maintenance, exclusive of rent, makes the annual cost of operation $800 for a battery equivalent to the smallest commercial size of dynamotor, while this machine, which uses only the current required for two incandescent lamps costing less than two cents an hour, requires an annual expense of but $150.

WIRELESS TELEGRAPHY AS IT IS.

THE present status to which wireless telegraphy has been developed on the Marconi system, which is the only system, by the way, that has met with any success on a commercial scale, is given in the following interesting letter from Prof. J. A. Fleming, written in London on April 7th, of the present year:

"During the last few days I have been permitted to make a close examination of the apparatus and methods being employed by Signor Marconi in his remarkable telegraphic experiments between South Foreland and Boulogne, and at the South Foreland lighthouse have been allowed by the inventor to make experiments and transmit messages from the station there established, both to France and to the lightship on the Goodwin Sands, which is equipped for sending and receiving ether wave signals. Throughout the period of my visit messages, signals, congratulations and jokes were freely exchanged between the operators sitting on either side of the Channel, and automatically printed down in telegraphic code signals on the ordinary paper slip at the rate of 12 to 18 words a minute. Not once was there the slighest difficulty or delay in obtaining an instant reply to a signal sent. No familiarity with the subject removes the feeling of vague wonder with which one sees a telegraphic instrument merely connected with a length of 150 feet of copper wire run up the side of a flagstaff begin to draw its message out of space and print down in dot and dash on the paper tape the intelligence ferried across 30 miles of water by the mysterious ether.

"I cannot help thinking that the time has arrived for a more generous appreciation by his scientific contemporaries of the fact that Signor Marconi has, by minute attention to detail, and by the important addition of the long vertical air wire, translated one method of space telegraphy out of the region of uncertain delicate laboratory experiments, and placed it on the same footing as regards certainty of action and ease of manipulation, so far as present results show, as any of the other methods of electric communication employing a continuous wire between the two places. This is no small achievement. The apparatus, moreover, is ridiculously simple and not costly. With the exception of the flagstaff and 150 feet of vertical wire at each end, he can place on a small kitchen table the appliances, costing not more than £100 in all, for communicating across 30 or even 100 miles of channel. With the same simple means he has placed a lightship on the Goodwins in instant communication, day and night, with the South Foreland lighthouse. A touch on a key on board the lightship suffices to ring an electric bell in the room at South Foreland, 12 miles away, with the same ease and certainty with which one can summon the servant to one's bedroom at a hotel. An attendant now sleeps hard by the instruments at South Foreland. If at any moment he is awakened by the bell rung from the lightship, he is able to ring up in return the Ramsgate lifeboat, and, if need be, direct it to the spot where its services are required, within a few seconds of the arrival of the call for help. In the presence of the enormous practical importance of this feat alone, and of the certainty with which communication can now be established between ship and shore without costly cable or wire, the scientific criticisms which have been launched by other inventors against Signor Marconi's methods have failed altogether in their appreciation of the practical significance of the results he has brought about.

"The public, however, are not in the least interested in learning the exact meed of merit to be apportioned to various investigators in the upbuilding of this result. They do, however, want to know whether the new method of communication across the Channel, established by the expenditure of a few hundred pounds, will take the place to any considerable extent of submarine cables which have cost thousands of pounds to lay and equip. They do also desire to learn what reasons, if any, will prevent every lighthouse around our coasts from being forthwith furnished with the necessary apparatus for placing it in instantaneous and secure connection with the mainland. They also hope to hear that the methods can be applied to enable ships to be able in addition to communicate instantly in case of need with shore stations. To understand how far these things can be done, and to appreciate the necessary or present limitations of the method, it is requisite to explain that each vertical wire or rod connected to a Marconi receiving or sending apparatus has a certain "sphere of influence." Signor Marconi has proved by experiment up to certain limits that the distance to which effective signaling extends, varies as the square of the height of the rod. A wire 20 feet high carries the effective signal one mile, 40 feet high four miles, 80 feet sixteen miles, and so on. Up to the present time he has not discovered any method of shielding any particular rod so as to render it responsive only to signals coming from one station and not from all others within its sphere of influence. In spite, however, of what has been said, there is no inherent impossibility in attaining this desired result. At present all signals sent from South Foreland to France affect the receiver on board the Goodwin lightship. But this offers no difficulty. In an ordinary electric bell system in a hotel, the servant recognizes the room from which the signal comes by means of a simple apparatus called an indicator, and a very similar arrangement can be applied to distinguish the origin of an ether wave signal when several instruments are at work in a common region. Subsequent inventions, as also perhaps the promulgation of some necessary Board of Trade regulations for the use of the ether, will prevent official ether wave receivers from being disturbed by vagrant electric waves sent out by unauthorized persons in their neighborhood. The practical upshot, however, of the matter is that at present if more than two stations are not established within certain regions, these stations, pair and pair, can

communicate with each other freely and regularly by means of ether wave signals sent out and received by long vertical rods or wires. No state of the atmosphere, and neither darkness nor storm, interrupts, so far as yet found, the freedom of communication.

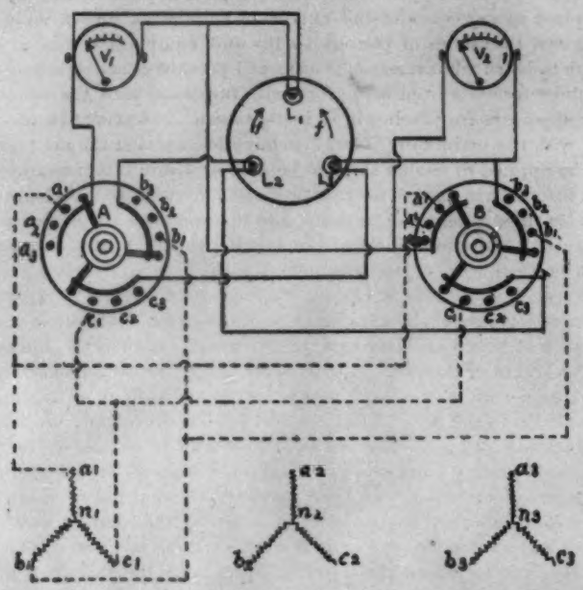
"Up to the present time none of the other systems of wireless telegraphy employing electric or magnetic agencies have been able to accomplish the same results over equal distances. Without denying that much remains yet to be attained, or that the same may not be effected in other ways, it is impossible for any one to witness the South Foreland and Boulogne experiments without coming to the conclusion that neither captious criticism nor official lethargy should stand in the way of additional opportunities being afforded for a further extension of practical experiments. Wireless telegraphy will not take the place of telegraphy with wires. Each has a special field of operations of its own, but the public have a right to ask that the fullest advantage shall be taken of that particular service which ether wave telegraphy can now render in promoting the greater safety of those at sea."

Generation

THREE-PHASE SYNCHRONIZING METHODS.

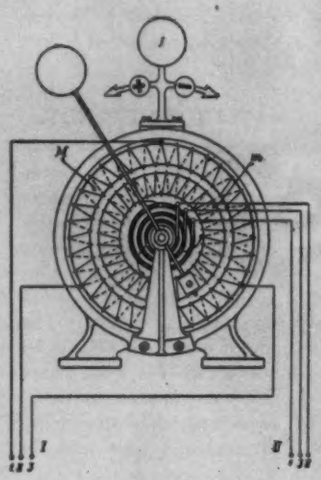
THE method adopted by the Siemens & Halske Electric Company for synchronizing three-phase generators possesses the advantage that if the machines are not running synchonously, the extinction of the lamps, which are arranged in a triangle, will travel around the triangle in one direction or the other according to whether the incoming generator is running below or above the speed of synchronism, thus indicating at once whether it is necessary to increase or diminish the speed of the incoming machine.

In the accompanying figure, *A* and *B* are two switches, each provided with as many arms (3) as there are generators, and a corresponding number of contacts. Corresponding terminals of the generators and switch contacts are indicated by the same letters. By means of the switch *B*, the terminals of any incoming machine may be connected to the 'bus bars through the synchronizing lamps L_1, L_2 and L_3. If the connections of the switch contacts were symmetrical, then the three lamps would at any instant be raised to the same incandescence. It will be noticed, however, that the connections are not symmetrical, the long segment contact corresponding to b_1, b_2, b_3, in switch *A* being in connection with the segment corresponding to c_1, c_2, c_3 in switch *B*. The result is that when the *a* circuits of two machines happen to be in phase, so that—with the switches *A* and *B* in their proper positions—the lamp L_1 is extinguished, the *b* circuit of one machine is connected to the *c* circuit of the other, and *vice versa*, the lamps L_2 and L_3 being raised to incandescence. The main switch is closed at the instant when L_1 is dark, and when the rate at which the extinction travels around the triangle shows the machines are running very nearly in synchronism. The voltmeters V_1 and V_2 are provided for greater sensitiveness.



SYNCHRONIZING THREE-PHASERS BY THE SIEMENS-HALSKE METHOD.

The Mueller method of synchronizing three-phasers not only shows whether two alternators are in phase, but also whether the unloaded machine, which is to be thrown in parallel with the other, is running too rapidly or too slowly. In this result it is similar to the Siemens-Halske method, but it is accomplished by entirely different means. In the adjoining figure the outside magnet *M* is stationary and the windings are connected to the 'bus bars, while the second or interior magnet *m* is capable of rotating and is in circuit with the alternator which is to be brought into phase with the currents in the 'bus bars. The connections are so made that the two rotating fields which are produced will revolve in the same direction, and there will then be no rotation of the movable part when the frequencies of the two currents are the same; but a torque will be produced when the frequencies are different and the rotation will then be in the same or the opposite direction to that of the induced fields, according as the frequency of alternator No. II is smaller than that of alternator No. I. A pointer with a signal dial is screwed to the movable part as shown; a deflection to the right or negative direction means that the speed of the alternator is too slow, and to the other side too fast. The mechanical power developed by this apparatus is quite great and it can therefore also be used for operating a regulator.



In a simpler and more effective modification of the Mueller method, there are two such fields revolving in opposite directions over stationary cores, both of which act on a third ring magnet, also stationary, which operates the signal; the latter is accomplished by means of a row of incandescent lamps, connected to this ring winding, and which will then be illuminated in succession so as to give the appearance of a wave of light moving in one or the other direction around a circle. When the two frequencies are the same this wave of light will appear to stand still, but when the speeds are different the movement of the wave of light will show whether the frequency of the machine to be connected is too high or too low, the speed of the rotation being an indication of the difference between the frequencies. Synchronism, in addition to equality of frequency, will exist only when certain special lamps are illuminated, and the machines must therefore be coupled only when the slowly moving wave of light appears over those lamps; this position may be indicated by an additional colored lamp. The apparatus may be simplified by winding both coils on the same core, the incandescent lamps being connected to a winding on a separate core; or, it may also be possible to have all three windings on a single core.

Roughly speaking, the generating capacity of a dynamo increases in proportion with the cube of the linear dimensions, while its radiating surface increases only in proportion with the square.

The *Canadian Electrical News*, of Toronto, characterizes the recent articles in the JOURNAL on the Kootenay-Rossland transmission, as being "a very complete description."

Industrial

In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

SEVEN 2000-HORSEPOWER TRANSFORMERS.

THERE are many interesting electrical installations at Niagara Falls in the plants of the great manufactories that have been located there by reason of the cheapness of electrical power derived from a generating station of the world-famous Niagara Falls electric plant. Of all these installations, that of the Union Carbide Company is most important in volume of electric energy consumed in its manufacturing processes. When the facilities of these works are fully developed, there will be in practically constant use not far from 25,000 electrical horsepower, the entire output of five of the great generators in the central station of the Niagara Falls Power Company. Such an enormous consumption of power has led to radical departures on the part of the electrical manufacturing companies from standards heretofore maintained for apparatus of the character called for in this work. To meet the requirements of this service most efficiently and with the least likelihood of interruption of service, very large units were called for. The design of these units has taken the engineers of electrical manufacturing companies into new realms, with the result that the eyes of the engineering world are centered on the apparatus that has been installed to meet the requiremeuts here arising. It has, therefore, proven a matter of great surprise, as well as keen interest in manufacturing circles, that contracts for this installation should have been awarded a company not heretofore favored with any of the great orders that have been placed for machinery in the various Niagara Falls installations. Such action on the part of the Union Carbide Company is recognition of the success that has been achieved by the contractors in this instance in the design and manufacture of the particular form of apparatus called for in this installation.

In the manufacture of calcium carbide, a product, by the way, the consumption of which has assumed tremendous proportions, the electric current is an essential element of the manufacturing system. Indeed, calcium carbide is formed as a result of chemical action taking place when the fundamental elements of the carbide are introduced into the electric arc. All electric current used by the carbide company is transmitted from the great generating station of the Niagara Power Company at a high electrical pressure. Before it can be applied in the carbide furnaces, this electric current must be reduced in pressure to 110 volts. The transformers, as they are termed, which accomplish this reduction of pressure, constitute the apparatus which is attracting so much engineering interest. Heretofore the largest static transformers in practical service have been single-current of 1200 horsepower output. This transformer was considered an enormous one and at the time of its manufacture created great interest. The new units, however, which the carbide company has installed are of 2000 horsepower output each, and are seven in number. Nothing of the kind has been heretofore heard of in either foreign or American engineering practice. Much skepticism was expressed as to the ability of the company securing the contract to accomplish the results guaranteed. One well-known foreign engineer who has followed American practice very closely and been greatly interested therein, even went so far as to say that the temerity of the manufacturers astounded him. Every claim of the builders, however, and every argument advanced by them in advocating the construction of such large units, has been verified by the complete success of the apparatus so far delivered and installed.

The first of these great units was installed about four months ago and has been carrying continuously since that time its full load with most eminently satisfactory results in all respects. On this page is given an illustration of this apparatus as it appears in actual service. In outward appearance it is nothing more than a great iron shell. Inside, however, is the transformer proper, made up of tremendous windings of pure copper, grouped so as to accomplish the results desired. Surrounding these great copper windings is a large endless copper cooling coil through which a constant stream of running water is passing. This cooling coil, together with the transformer proper, is completely immersed in oil. This oil circulates freely through the windings of the transformer and carries away by both conduction and convection the heat losses arising in the transformer. This heat reaches the cooling coil by the circulation of the oil and is transferred to the running water in the cooling coil and thus carried out of the transformer entirely. Each of these units has the enormous weight of 40,000 pounds in complete form. As one stands beside the apparatus, it seems incomprehensible that so silent an agent

THE LARGEST TRANSFORMER IN THE WORLD.

should be performing work of such tremendous magnitude. The builders of this apparatus are the Wagner Electric Manufacturing Company of St. Louis, a company which has now attained a world-wide reputation for the manufacture of this form of electrical machinery, and also several other lines of apparatus largely used in the alternating-current field. This progressive company of the West entered the lists against the two great companies of the East who have heretofore monopolized the business at Niagara, and in successfully carrying out their contract, have set a pace in the electrical industry which means an immediate innovation of new ideas the world over in this particular form of electrical machinery.

To the Wagner company is now due the credit of having not only built the largest units ever constructed in static transformers, but also the praise for introducing the highest voltage transformers in large units that have ever been placed in practical service. The latter apparatus installed on the circuits of the Telluride Power Transmission Company at Provo, Utah, have been most successfully operated about two years on a line pressure of 40,000 volts. The units in this service are of 300 and less kilowatt capacity each.

The development of the Wagner Electric Manufacturing Company has been one of the marvels of this electrical era. Seven years ago this company was organized with a capital stock of

$25,000 to manufacture one or two small electrical specialties. St. Louis, as a manufacturing center, and the rapid opening up of the electrical field, resulted in an expansion of this company into one with a very large capitalization, until now the industry ranks as the leading one of the West in its particular electrical lines. The company has branched out until its output is now being shipped to all parts of the world, and wherever it is sent is recognized for its excellence. Indeed, the aim of this company has been to build nothing but high-grade apparatus and the present influential position occupied by it in the electrical field is entirely the result of this broad gage policy. The company does not pretend to go into all fields of electrical machinery, but confines itself strictly to a number of lines of product of which static transformers head the list, with a new form of single-phase, alternating-current motor, indicating switchboard instruments, direct-coupled ventilating fans, storage battery charging outfits, switchboard work and direct-current motors and dynamos, constituting the other chief products.

An immediate consequence of the success achieved in the equipment of the plant of the Union Carbide Company at Niagara Falls has been to award the Wagner company the contract for the similar equipment of the great Canadian carbide plant now building at Ottawa, Canada, in which will be installed at the start twenty units of 150-kilowatt output each.

THE LOCKE PATENT SUSTAINED.

THE public will be interested in learning that the controversy over the inventorship of what is known as the Locke insulator, manufactured by Fred M. Locke, of Victor, N. Y., and comprising two or more shells of porcelain nested together and fused together with glaze, has been decided by the Examiner in the Patent Office to be the invention of Mr. Locke.

Mr. Locke filed his application for letters patent in February, 1897, and, in August of the same year, Mr. Boch, of R. Thomas & Sons Company, of East Liverpool, Ohio, filed an application for the same thing. An interference was declared between the two applications and also between Mr. Locke and a patent granted March 8, 1898, to Mr. Boch, which comprises substantially the same invention, except that the parts were fused together with extra glaze. Interference proceedings have been pending since September, 1897, and a couple of weeks ago the Patent Office decided that Mr. Locke had proved "that Locke was the first to conceive, disclose and reduce to practice the invention in issue; judgment of priority is awarded to Fred M. Locke."

And in the second interference with the patent of Mr. Boch the Examiner held that "whichever party is entitled to prevail as to the issue in one interference is equally entitled to prevail in the other; the fact in this instance, the burden of proof is upon Locke and that Boch is the patentee is of no moment, for to the Examiner's mind, Locke has established his claims of priority beyond a reasonable doubt. Judgment of priority of invention is awarded to Fred M. Locke."

Mr. Locke states that the patent in due time will be issued to him, and that all persons purchasing this class of insulators will be liable to him for damages and royalties for such use after the patents have issued.

NIAGARA FALLS PRINTS NEWSPAPERS.

RECENT additions to the power station of the Niagara Falls Power Company have enabled an increased supply of electricity to be utilized in the city of Buffalo, which lies twenty-six miles distant from the falls. The Westinghouse Electric and Manufacturing Company recently installed four 5000-horsepower generators in the power house of the Niagara Falls Power Company, doubling the original capacity, and have now under construction two more generators of the same size, which will increase the total to 50,000 horsepower.

The city of Buffalo is taking advantage of its proximity to this source of power, and every day applications to new industries are being made. The Great Northern Elevator and the Electric Elevator and others are exclusively operated by electrical motors equipped by the Westinghouse Electric and Manufacturing Company. This latter enterprising firm are now equipping the press-rooms of the *Buffalo Express*. This is the first newspaper of Buffalo to use the power of Niagara. By the end of the month it is expected that the installation will be completed, and the apparatus in good running order. Thenceforth every copy of the *Express* will be printed by power brought from Niagara, and the readers will be reminded in a visible and tangible form every morning of their proximity to this stupendous waterfall.

WAGNER COMPANY ITS OWN SALES AGENT.

The San Francisco office of the Wagner Electric Manufacturing Company desires the announcement made that the arrangement heretofore existing under which the California Electrical Works acted as selling agents of the Wagner company for California, Nevada and Arizona, has been annulled and that hereafter the business will be handled direct from the company's San Francisco office, No. 120 Sutter street.

TRADE LITERATURE.*

"Water Wheel and Steam Engine Governors." A general description of the Lombard Water Wheel Governor, together with reproductions of speed diagrams showing the degree of regulation which they have produced under various conditions in actual practice. The pamphlet is illustrated and contains letters showing satisfactory use in many prominent plants. 32 pages, 9x6 inches. *Lombard Water Wheel Governor Company*, 61 Hampshire street, (Roxbury District), Boston, Mass.

General Electric Bulletins. New bulletins were issued during August as follows: No. 4196, "Prices Paid for Street Arc Lighting in the United States;" No. 4197, "Automatic and Hand-Feed Electric Projecting Lamps;" No. 4198, "Thomson Astatic Instruments for Continuous-Current Switchboards;" No. 4194, "Magnetic Blow-Out Automatic Circuit Breakers for 500-volt, D-C. Circuits;" No. 4199, "Carbon-Feed Series Enclosed D-C. Arc Lamps;" No. 4202, "Type I S, A-C. Induction Motors for Single-Phase, 60-cycle, 104 to 115 volt circuits." *General Electric Co.*

Literature.

THE STEAM ENGINE INDICATOR, by F. R. Low. Size, 5½x9 in., 208 pages, 114 figures and 10 tables. Published by the Power Publishing Company, World Building, New York. Price, $1.50.

This work consists of directions for the selection, care and use of the steam engine indicator and the analysis and computation of the diagrams therefrom. It is compiled from the regular issues of *Power*, with revisions and extensions comprising numerous tables.

A book of this sort, appearing under the auspices, one might say, of such a publication as is *Power*, and from the pen of such an authoritative writer as is F. R. Low, its editor, calls for no criticism — it is above criticism. *Power* is too strongly intrenched in the minds of the steam engineering fraternity of the world to require introduction thereto, and the character of its invaluable articles is by far too well known to be elaborated upon. What, then, is to be expected when a line of these articles has been gone over with, redigested, rearranged, partly rewritten and supplemented by much additional matter and such tables as are necessary to render the subject matter full and complete? All steam engineers will know what to expect, and as the work is to and for them, the bare announcement of the appearance of the publication tells all there is to be said concerning it.

It may be added for others, however, that the book is a thoroughly practical, simple and exhaustive treatment of the methods of using, and of profiting by the use of, the instrument that is above all others, the key to the attainment of highest possible efficiencies in steam engine building and operation.

*Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY, POWER AND GAS. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.